AC 2007-2800: PREPARING ENGINEERS FOR THE GLOBAL SUPPLY CHAIN: THE CASE OF AUTOMOTIVE PARTS IN CHINA

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Preparing Engineers for the Global Supply Chain: The Case of Automotive Parts in China

Prior to World War Two, national suppliers of goods dominated their domestic markets enjoying monopolies or oligopolies. Supply chains were internal and often local as well; vertical integration was common and barriers to entry, such as economies of scale and import duties, served to prevent upstart competitors from encroaching on national markets. Product design and development was done inside a single company, or within a region, or in a single country. Obviously, this is changing rapidly and outsourcing and extended supply chains have become the norm.[1]

Engineers working in global supply chains must possess a range of skills not required in either a vertically integrated company or in a purely domestic supply chain. A common model for China-based sourcing involves designing and assembling the overall product, such an automobile, in the U.S. and seeking suppliers for many or most components elsewhere. Likely candidates for sourcing in China include commodities such as fasteners and brake pads as well as high labor content products such as sun visors, castings, and wire harnesses. Design-responsible engineers in the U.S. must manage systems producing integrated components whose design and production may be done 12,000 miles away.

Beyond the complexities of product design, engineers in the global supply chain require mastery of computer-aided design (CAD) and computer-aided engineering (CAE). Additional skill sets include global quality standards such as ISO/TS 16949, communication techniques such as data sharing and e-conferences, sensitivity to language and cultural issues, and cost issues. CAD support would include multiple CAD systems (Catia, I-Deas, Solidworks, SolidEdge, Inventor, AutoCAD). CAE support would involve linear analysis, non-linear analysis, finite element analysis (FEA), and simulations such as Impact/Crash. Communications issues might include Step and IGES direct transfer and e-conference via computer or video. Knowledge of cost issues must incorporate the fact that both labor and engineering costs in China run at 5-10% of U.S. rates.

Capstone courses can integrate many of these techniques and provide senior students with actual data and examples from current faculty projects.

1. Overview

As documented by Tucker[2], international supply chains are increasing in scope and complexity. “The trend in manufactured goods is toward more outsourcing;

greater complexity in international supply chains… U.S. manufacturers may reduce the cost of labor by as much as 90% by simply siting production faculties in Mexico; even greater savings are possible with an Asian source. According to Diana Farrell of McKinsey's Global institute, "A multinational firm can hope to lower its costs by as much as 50-70%." by globally reorganizing production.[3] China has exploded with double digit growth rates over the last decade giving rise to the "China Price" phenomenon of the last few years.[4] In 2003, China became the third largest global trader after the U.S. and Germany.[5] The Economist magazine opines: "China's role as the global economy's manufacturing hub is unstoppable…".[6]

The issue of automotive manufacture outsourcing is ubiquitous in the mainstream press these days.[7] Generally researchers claim that comparative advantages and low labor cost are the drivers that has caused investors to invest in extended global supply chains. They focus their studies on the cultural differences; unemployment management, business competence and even political opportunities.[8] Previous research on outsourcing has been carried out from a number of perspectives and theoretical frameworks.[9] However, there are not many studies concentrating on the impact of extended, global supply chains on the preparation of engineers. Many of our Eastern Michigan University (EMU) students expect to work for automotive manufacturing and engineering companies; outsourcing by means of extended transnational supply chains affects their careers and daily lives.

In order to prepare our engineering technology students for their future careers, it is vital for them to know what new challenges are posed by the outsourcing environment. How can we grow, educate, attract and retain the best and brightest scientists and engineering students?[10] Besides the obvious cultural differences inherent in global sourcing, design support, engineering support, quality control, and logistical support are significantly different in developing and maintaining global supply chains. This research champions a new capstone course for senior students with a Mechanical Engineering Technology major. This course will help students practice engineering activities in an outsourcing environment and find the protocol or define a prototype appropriate for development and manufacture using global sourcing.

To perform outsourcing successfully and provide qualified professionals for companies, the course has to establish a complete outsourcing/supply chain management system to operate, manage and maintain critical sourcing issues. This includes how to manage the design support, engineering support, logistic support and remote risk management. This course is to be called "Total management of outsourcing". This paper will discuss outsourcing management issues in education. It will provide a framework for developing well-educated and skilled manpower to support business strategy transfer and change in the outsourcing environment.

In the university setting, it is a common practice to provide the capstone course to senior students. Senior students will work on the project by applying all the key knowledge learned during the course of university study. Traditionally in Engineering Technology, the capstone course will provide students an opportunity to combine all knowledge and technology together to implement a real world project. Most of our students have never had a chance to address topics on outsourcing prior to this. In this newly developed capstone course, we provide for students a systematic, total management and methodology of outsourcing, instead of partial, or special field outsourcing management. It is the first time a capstone course has been used in order to help students understand and study the real world of offshore outsourcing. Through operating, managing and analyzing in real world applications, our students receive a useful and highly beneficial experience. The capstone course has implemented a match of education with practice. Half of our students in Mechanical Engineering Technology are from the various automotive manufacturers, which are currently facing the challenge of total management of outsourcing. Their companies have realized that an outsourcing strategy is a survival strategy for the automotive manufacturing industry.

The discussion is structured by following the research of outsourcing engineering support methodology and developing a protocol –a capstone course for senior students.

2. Developing a Protocol -Outsourcing Management Capstone Course

In an outsourcing environment, design support, engineering support, logistic support, as well as quality control will be changed greatly. Therefore, the capstone course structure needs to be modified accordingly. The following two sections will discuss the differences of existing capstone courses and the newly developed capstone course for total management of outsourcing.

2.1 Existing Capstone Course for Engineering Technology students

Traditionally, we have a capstone course for Engineering Technology students in order to combine all that they have learned during the course of their four year Engineering Technology study. It will typically include following aspects:

1. Requirements for designing an engineering device (e.g. gear hub, sunvisor in a vehicle);
2. Designing of the components and assembly (involving individual and group);
3. Completing the kinematics or dynamic analysis (depending on the problem, some project more on kinematics, some projects more on dynamics). FEA analysis if necessary;
4. Create 2D drawings (involving GD&T);
5. Reports and presentation

In the traditional capstone course of Engineering Technology, the students operate in a closed environment which is based on our CAD/CAE lab and mechanical and

manufacturing labs. Sometimes, we will bring experienced engineers for consulting as well. However, the current business environment, especially in automotive industry, is changed dramatically due to the impact of outsourcing. Most of our students recognized that the knowledge they learned in the university or in industrial practices might not be enough to compete, especially considering new outsourcing challenges. That is why this new capstone course is needed to provide students additional knowledge in order to handle the engineering issues emerging in an outsourcing environment.

2.2 Outsourcing Management Capstone Course

The faculty in the Mechanical Engineering Technology at EMU developed a capstone course for our senior students in Engineering Technology so that they will have opportunities to experience a real world example of outsourcing for automotive mechanical components. The students were divided into several groups. Each group plays a role in the actual outsourcing environment. By expanding on the capstone course method and personalizing it for business challenges and training needs, this capstone course has developed a unique training approach that will give students the experience of a whole cycle of outsourcing management. From a technical point of view, students will perform similar activities such as design, engineering analysis, quality control and logistic support. However, all these activities will add to the challenge of outsourcing. It is also apparent that students will get more engineering management training as part of this course.

2.3 Real World, Real Project

The students were teamed up with a local automotive company where students were involved in outsourcing development and practiced in an automotive design, service and distributing company. Their target market was outsourcing to a Chinese automotive supplier market. It is obvious that the Chinese automotive supplier market is one of typical outsourcing environment.[11] However, this practice also will fit in other outsourcing environments as long as the following conditions exist:

1. Targeted region has auto industry Tier 1 and Tier 2 global experience;
2. Targeted region has very strong cost advantage;
3.Targeted region has certain level of engineering and technical support;
4. Targeted region has potential automotive components demands;

In this course, each group will develop, research, and complete data transfer, technique design, and logistical support. They will complete following work.

1. Survey and strategy planning;
2. Design support;
3. Engineering support;
4. Logistics support;
5. Risk management.

3. Total Management of Automotive Manufacturing Outsourcing

In this real case study, students directly deal with CAD design support, engineering change, and supply chain logistics management and risk management. However, before they can directly involving the design, engineering, and supply logistics management, they have to know the target outsourcing market. [12] That is why the first task for each group is to perform a market survey which will narrow the scope of outsourcing and form a strategy for the particular company. Certainly, the method they have used in this project could be applied to similar projects in future capstone course.

3.1 Market Survey and Outsourcing Strategy Planning

For any outsourcing project, the company needs to know the targeted source market. Therefore, it is always necessary to do a broad range of market surveys in order to form an outsourcing strategy. Hence, the first, and one of most important tasks for our students, is to perform the collection of information, investigating the market, and create an evaluation standard system. In this project, students will survey 5-8 companies in that region where there are similar products produced in different companies. The following items from each company are keys in the student market survey:

1. Company general information: Name, address, organization, size, annual sales, total assets, annual sales based on products, ownership;
2. Manufacturing Capabilities
3. Current and potential capabilities for chosen products, which companies to supply, which car types to supply, in-house and sub-contract parts, material supplier companies, major equipments;
4. Technique advantages:
CAD/CAE/CAM support capabilities, quality control, technology cooperation, tooling capabilities, new development cycles, mass production lead time, export/import experience;
5. Price and cost on existing products
Parts, components and assembly cost estimation and products sale’s price.

		Suppliers Profile			
		Company 1	Company 2	Company3	Comp
1	**1. Company Profile**		1. Company Profile		
2	1.1 Name	XXX ZhouShan WanTong	1.1 Name XXX (NingBo	XXX XXX Ltd	XXX XXX
3	1.2 Address	XX XX, ZhiJiang Province	1.2 Address XXX E-Mail:	Ningbo, Zhi Jiang	Wuxi, Jian
4	1.3 Contact	daimay@mail.zsptt.zj.cn (022	1.3 Contact	www.XXX.com, hym@XXX	www.XXX
5	1.3.1 Contact CEO	Jiang XXX (XXX-XXX-XXX)	1.3.1 Contact CEO XXX	He XXX (XXX-XXX)	Wu XXX
6	1.3.2 Contact Sales	Shi XXX (XXX-XXX)	1.3.2 Contact Sales XX	Zhou XXX(XXXX)	
7	1.4 Size (Employe)	450 total	1.4 Size (Employe) 90人	260 total	285 total
8	1.4.1 CAD designer, Molding	35 CAD, Molding	1.4.1 CAD designer, M	15 CAD, Molding	31 techinc
9	1.4.1 management		1.4.1 management 12	20 managers	32 manag
10	1.4.1 field		1.4.1 field 12000 12.	195 workers	170 worke
11	**1.5 Annual Sales**	110 mil Yuan (~ $13.75 mil)	1.5 Annual Sales	40 mil Yuan (~ $5.00 mil)	??
12	1.5.1 Annual Sales (after tax)	8 mil Yuan (~ $ 1 mil)	1.5.1 Annual Sales (after tax) (= $1,212 Mil)		
13	1.5.2 total asset (investiment)		1.5.2 total asset (inves	25 mil Yuan (~ $3.125 mil)	62 mil Ya
14	**1.6 Annual Sales (Percent**	10% of total = $1.375 mil	1.6 Annual Sales (Percen	85%	??
15	1.7 Upper tier company	ZhiJiang DaiMay	1.7 Upper tier company		
16	1.7 Ownership	China private	1.7 Ownership (priva	China Private	20% Chin
17	1.9 Export Capabilities				
18	1.9.1 existing export expertise	Yes	No	No	Yes
19	1.9.2				
20					
21	2. Part 1 Manufacturing Capabilities				
22	**2.1 Quantities(current cap**	800K set	2.1 Quantities(current ca	400,000 Sets	500 K
23	**2.1.1 Quantities (current**	200K set	2.1.1 Quantities (curren	200K sets (for different typ	60K sets
24	2.2 Supply to Companies	Shanghai GM, Shanghai VW,	2.2 Supply to Companies	(more than 8 china car ma	Shanghai
25	2.2.1 Supply car types	sedan, pickup, middle size tru	2.2.1 Supply car types	sedan, pickup, middle size	Sedan
26	**2.3 In-House vs. sub-cont**	all major parts in house	2.3 In-House vs. sub-con	all major parts in house ??	80% parts
27					
28					
29	3. Technology Capabilities		3. SunVisor Technology Capabilities		
30	3.1 CAD/CAM/CAE	in-house CAD to CAM, and I	3.1 CAD/CAM/CAE AutoCAD2002、Pro/ENGNEE		in house
31	3.2 Equipments	EPP, etc. (has all)	3.2 Equipments 10T-240T	EPP, etc. 4 set special Sui	PU, EPP
32	3.3 Quality Control	ISO9002, QS9000, ISO/TS16S	3.3 Quality Control ISO90	ISO9001 pass	ISO9002,
33	3.4 Technology coorperation	German, Telfor(?) Simens	3.4 Technology coorperation		
34	3.5 New product develop cycle	9-22 weeks (from design to s	3.5 New product develop cycle 60天 (60 day)		120 days
35	3.6 Mass production lead time	4 week (from sample to first	3.6 Mass production lead time 100天 (100 day)		
36	3.7 SunVisor special designer		3.7 SunVisor special des	2 sunvisor designer	
37	3.8 SunVisor tech (PVC/EPP)	both capable	3.8 SunVisor tech (PVC/E	both capable	both cap
38					
39	**4. Materials**	All in local, no import	4. Materials	All in local, no import	
40	4.1 all materials		4.1 all materials (local buy)		
41					

Figure 1. Plastic Molding Company Profile Survey

Figure 1 shows the survey of plastic molding companies in one region of China in which our US company will target for outsourcing some of the plastic injection molding products. After a broad search for possible candidates for outsourcing,

we also developed one effective procedure to narrow down one or two strategies of outsourcing for small and medium companies.

The process of narrowing down the outsourcing strategy is called the "supplier auditor" procedure. Figure 2 shows the procedures to decide on the right type of outsourcing supplier and arranging work offshore. The concept of supplier auditor is very common in the automotive OEMs when they want to choose a supplier. However, in an outsourcing environment, there is no foolproof way to choose the supplier. Our students inventively applied this concept into their outsourcing strategy and it was successfully implemented. From this auditing process, the company narrows their outsourcing strategies very efficiently. This supplier auditor procedure is marked as one of the achievements of our students in this course. Certainly, from the outsourcing environment survey and outsourcing strategy selection, students have much deeper understanding of the outsourcing environment. Most of the students have only learned one or two courses in engineering management during their studies. Upon the first task performed in this capstone course, they have learned and practiced the concept of engineering management a great deal.

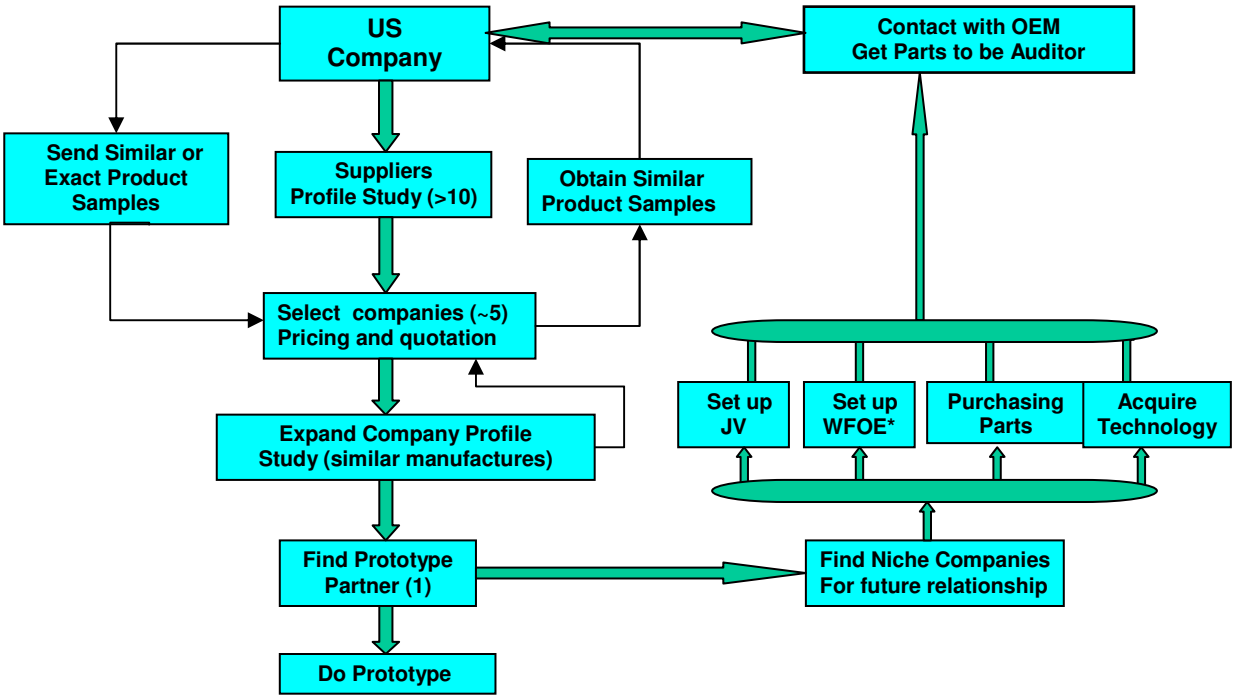


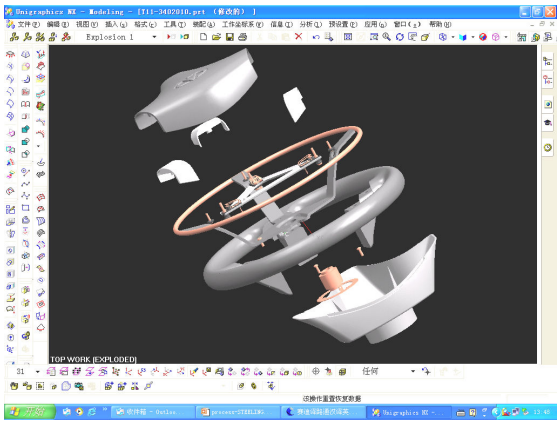
Figure 2 Supplier Auditor Procedure

3.2 Managing Design Support

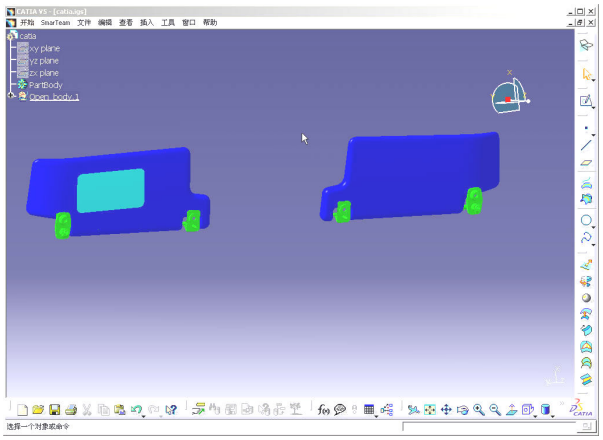
In order to implement an outsourcing strategy, we have to communicate well with our oversea counterparts. Basically, all of our students have learned one or two CAD software formats to complete design during their course of studies. When they are working (or will work) at certain company that uses a CAD tool to

develop designs, most of time, it is only necessary to access one or two CAD tools (the design and engineering environment without outsourcing). However, the outside world may use totally different types of software, and quite possibly, different versions. There are more than ten major CAD design software formats which are popular in the engineering world. In order to make the communication successful in terms of design support, students are forced to learn other CAD software quickly. They found design support has different meanings in the outsourcing environment.

1. It is necessary to have deep knowledge on one or two CAD software types. However, it is also very important to be familiar with other CAD software because it will make our designers and engineers capable of communicating with engineers in other countries. After practice, the students find that it is not overwhelmingly difficult for them to be familiar with two to four additional CAD software types in a short amount of time. They respond to the challenges very positively. The result is their knowledge of design using CAD software is improved greatly. Figure 3 shows students design products using different software.



Design steering wheel with UG



Design Sunvisor with UG

Figure 3. Design products using different CAD software

2. In the outsourcing design environment, how to transfer the engineering data between different CAD software packages is the key. From the previous classes they learn that there are many different ways to transfer data, such as IGES, STEP, ParaSolid, e-drawing, or any direct file transfer. Theoretically, IGES file transfer is the most primary way of transferring data. Other methods are more sophisticated and advanced. In the outsourcing environment, however, the design data will be used for many different purposes, such as viewing or tooling. Most of the advanced data transfer methods cannot be successfully implemented. The primary method, using IGES file to transfer, is the most reliable way to transfer the data between two design environments.

3.3. Managing Engineering Changes

For any engineering project, engineering changes are the most frequent activities. More than 90% of the engineering activities are to manage the design and engineering changes.[13] It is especially challenging to manage engineering changes in different time zones and different worlds, which is typical in an outsourcing environment. There are many tools to assist in managing engineering changes. It is easy to say that electronic data exchanges could make changes seamless between two sides of the world. Students found that good and bad engineering change management could make a huge difference.

1. In order to use the different time zone most efficiently, it is necessary to keep in mind that, at the end of a business day of our working environment, the other partners could begin their work. If you don't update your work or assign certain workable tasks to your partner on the other side of the world, it is not a12 hour delay; - it is a 36 hour delay. To work like a team, it is wise to assign certain workable tasks (via e-mails or data transferring) to your counterpart before the end of your business day. This is so called working around the clock.
2. Electronic data transfer and e-mails will not make everything happen automatically. In most cases, it will not happen. It is not because engineers on other side are lazy or lack of cooperation. Most of the time, it is because most of the engineering changes are very rich in detailed background. It is very difficult to convey the whole situation through data transfer and e-mails. Without the background or in-depth explanation, it is obvious that nobody can understand the changes let alone implement them. Hence, "follow-up" is the key for successfully implementing the engineering changes. Students found that they needed to follow-up on every issue and every piece of data they sent in order to ensure successful coordination of the design change.
3. Certainly, traditional scheduling, status updates and issue lists are also particularly important in the outsourcing environment. Actually, if not in the outsourcing environment, status updates and issue lists, sometimes, are not very much up to the date because most engineers are all together and get updated frequently. Typically, we all found that, when the status report and open the issue list are needed, it is out of date. However, in the outsourcing environment, these tools are the only methods to make sure the design and engineering issues are tracked and implemented on time.

3.4 Managing Logistic Support

Outsourcing has a direct impact on logistic operations. The development of a formal logistics strategy to guide a company through these changes is now more important than ever. The supply chain is different and much longer in the outsourcing environment. Therefore, the delivery logistics are also different. In this area, it is a truly eye opening experience for our students to understand the global supply chain and how it will affect the normal delivery logistics.

3.4.1 Supply Chain Management

Most of the US OEMs require their overseas suppliers to maintain a minimum of 4 weeks inventory. It will typically take more than 4 weeks to ship the parts from oversea suppliers, e.g. China suppliers. If this involves importation of raw materials from US for overseas manufacturing, it will add another 4 weeks for shipment. From a shipping cost point of view, it is most cost effective to ship quantities in one standard sea container (40 ft trailer at minimum). At the same time, most US manufacturing companies have already adopted the "lean and mean" manufacturing or Just-In-Time (JIT) manufacturing principles. It will require US raw material manufacture companies to prepare this particular order with a relatively long lead time. For example, it will take at least 4 weeks manufacturing time for a US fabric company to produce ten thousand of yards of fabric for any certain type. In this case, one round of the supply chain could take more than 20 weeks. In an outsourcing environment, "very long supply chain" is one of the most critical elements requiring management.

3.4.2 Delivery Logistics

Delivery logistics is one of the key components of supply chain management which deals with order tracking and fulfillment, determining warehouse locations, fleet management, and invoice processing. In an outsourcing environment, it is necessary to learn the delivery logistics and the costs involved in very detailed aspects. It is also important to understand the target country's export procedures which are the key part of delivery logistics. Figure 5 is one of the export operation procedures from our students' practice which are adopted by this US Company.

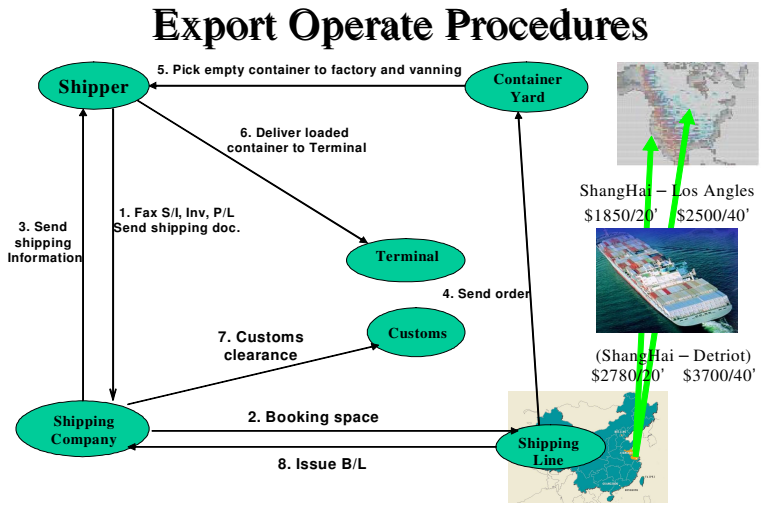


Figure 5. Export operation Procedures of a typical overseas supplier

3.5 Managing the risks of outsourcing and evaluate the effectiveness

As the economy becomes more globally oriented, managing the risk is another important task. Most of the risks are common knowledge such as currency fluctuation, human resources in foreign countries, evaporating distribution

channels, corporate governance, and unprecedented dependence on technology. In outsourcing, a company is relying on someone else to run certain business functions. If not properly managed, companies might be negatively affected by their operations. Effective risk management typically involves the application of pre- and post-loss mitigation techniques combined with varying levels of risk transfer. In our capstone course, we are more focused on the risks that occur in the design and engineering area. One of our proposals to deal with risk is so called "double processing" since some oversea operations are much lower cost compared with the cost here. The "double processing" could be adopted in following areas:

1. Double design and engineering teams

To handle the engineering and design risk, it is necessary to form similar functionality design and engineering teams on both sides. Both sides should have designers and engineers that do the exact same function. It could greatly reduce the risk of misunderstanding the design;

2. Double tools on both sides

The manufacturing happens overseas due to the cost savings of outsourcing. However, if there is some unforeseeable cause that the manufacturing is stopped and no parts ship here, this is the risk most companies are afraid of. Due to the low cost of the tooling in outsourcing, to produce second sets of tools to store here could minimize this risk in the short term.

3. Double inspections

US OEMs have adopted very tough quality standards in order to win in global competition. In general terms, they require their suppliers to adopt the same quality standards. One of the risks of outsourcing is the quality degeneration of the overseas low cost operation. To mitigate this risk, double inspections at the very beginning of a program are one successful way. Everyone must work very hard to establish and maintain an effective quality system which eventually obviates this expensive redundancy.

4. Conclusion

Through this outsourcing management capstone course, students not only consolidated their knowledge in their previously learned engineering technology courses, but also greatly expanded their engineering technology knowledge scope and, certainly, learned a great deal of outsourcing management. Our students have experienced collecting of information, dealing with CAD design, and engineering changes to supply chain logistics management which is so called total outsourcing management. With our students' efforts and dedication, this trial version of outsourcing management capstone course successfully helped a local automotive company to launch one of their projects by outsourcing to their oversea partner. Actually, this company has built up one Whole-Owned- Foreign-Enterprise (WOFE) in an overseas country recently to expand their outsourcing strategy.

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