

Engineering Management
Field Project

Feasibility of Starting a Waterjet Fabrication Plant in Amman, Jordan

By

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Preface

It has been my desire for a long time to investigate what it takes to start a water jet fabrication plant in Amman, Jordan to precisely cut marble, granite, and ceramics. I worked in the manufacturing and fabrication automation industry as a software solution provider for 14 years. During those times, I developed computer software solutions to convert CAD drawings of different formats to CNC machine readable programs that run on several CNC fabrication centers such as water jet, laser, plasma, oxy-fuel, punch press, and shear machines. Water jet machines have captured my interest the very first day I was introduced to them in the International Machine Trade Show, IMTS, in Chicago back in the middle of the 1990s. I have been drawn closer to water jet machines since I learned about their cutting performance and capabilities in the marble, granite, and ceramics materials. These materials present a strong interest to me since they are used heavily in the industrial, commercial, and residential construction fields in Jordan in particular and in the Middle East in general. These materials are also used in many places around the world.

Executive Summary

This project is an attempt to investigate the feasibility of starting a waterjet fabrication plant in Amman, Jordan to precisely cut marble, granite, and ceramics. The frame work of the feasibility study included analyzing the proposed product/service, market size, price and profitability, government regulations, culture and religion, and business infrastructure in Jordan.

Based on the findings detailed in this field project, it is feasible to start a waterjet plant operating at full capacity of the waterjet machine to produce and sell tiles that compete in quality and price with the local products. The table below shows the three-year operating statement for this new venture.

	2011	2012	2013
Rent	\$18,000.00	\$18,306	\$18,617
Sales estimate	\$835,380	\$861,277	\$887,976
Cost of goods	\$600,649	\$620,238	\$641,637
Gross margin	\$234,731	\$241,039	\$246,339
Operating expenses	\$38,200	\$39,384	\$40,605
Profit	\$196,531	\$201,655	\$205,734

Expense growth is based on the 2009 inflation rate (1.7%) for Jordan which is reported by the World Fact Book - managed by the United States Central Intelligence Agency. In addition, business growth rate is based on the 2009 GDP growth rate of 3.1% which is reported by the same agency.

Rent and operating expenses are based on responses obtained from questionnaires and interviews with local tile experts with a minimum of 25 years of experience and exposure to the customer demands for marble, granite, and ceramics.

Sales estimate are done based on the machine capacity of operating at 22 hours a day with two hours used for maintenance. It was not feasible to conduct a sales forecast using standard methods due to lack of historical data. However, during the business planning, a professional sales forecast should be conducted at full range.

The size of the market in Jordan and the Middle East at large can support this new venture. According to Jordan Investment Board, there are new projects in the construction field planned for the next five years totaling \$1.3 trillion dollars. In addition, Jordan has introduced many laws that protect foreign investments and investors. As a result, many construction projects such as the \$6 billion dollar renovation project in Abdali are taking off thereby boosting demands for marble, granite, and

ceramics. Moreover, Jordan has signed free trade agreements with the Arab states, the European Union, and the United States of America thereby opening exports to these countries.

Local and imported marble, granite, and ceramics tiles are commonly used in the constructions and decorations of buildings in Jordan. Waterjet cutting technology can be used to capitalize on cutting irregular shapes from locally produced marble and granite slabs as well as imported ones. The technology is very precise that it could compete with Spanish and Italian imported tiles especially that the labor rates in Jordan are five to six times less than those in Spain and Italy.

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Chapter 1 – “Introduction”

Water jet cutting technology has been in use for more than 20 years (Summers, 1993). The technology has become very advanced that today's CNC water jet machines can “cut materials with surprising speed, hitting accuracies of up to 0.001 inches. “Five or 10 years ago, that accuracy wasn't possible," says Adam Wysuph, an applications engineer at Mitsubishi. "A lot of people used waterjet as a roughing operation, then machined the part later. But today you can make finished parts from it, with a smoother edge and better quality than from a laser or plasma table.”” (Alpern, 2010). In addition, with continuous advancements in the water jet technology, water jet CNC machines are becoming more affordable and require less maintenance in comparison to other CNC cutting machines such as laser, milling, or stone-saw machines. Refer to Appendix A for an overview of the water jet cutting technology.

These characteristics– speed, accuracy, and affordability- of water jet machines has lead me to study the feasibility of starting a fabrication plant that uses water jet machines to cut marble, granite, and ceramics in Amman, Jordan. Such feasibility study can lead to the creation of a business opportunity that could be adopted by a new or an existing company familiar to the field of marble, granite, and ceramics.

Although several types of materials can be cut using water jet machines, my study will concentrate on marble, granite, and ceramics since they are widely used in constructions and landscaping in Jordan and in the Middle East.

The framework of this feasibility study will focus on the following aspects to introduce the water jet cutting services in the marble, granite, and ceramics (John Pappajohn Entrepreneurial Center).

- Product/Service
- The Market
- Price and Profitability
- Supporting Infrastructure
- Government regulations

Product/Service

A successful and complete feasibility plan should address the following aspects when introducing a new product/service to the market.

The plan should identify the purpose and the unique features or offering strategy of the product/service such as cost, design, quality, and capabilities. The plan should include sample images of the products that could be cut using water jet machines which distinguish them from the competition.

Product storage and care is also very important aspect in this feasibility study. The shelf life of the marble, granite, and ceramics is very long and can withstand

indoor and outdoor temperatures. However, in the modern urban atmosphere sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) attack calcite (CaCO₃) in marble exposed at rain-sheltered surfaces creating largely gypsum (CaSO₄·2H₂O) crusts that eventually exfoliate. In combination with carbon dioxide (CO₂) these gases erode the marble at unsheltered surfaces (Yerrapragada et al, 1996). Therefore, storage should ensure rain free environment. In addition, cigarette smoke may stain the surfaces especially for a prolonged exposure so the environment should provide smoke-free environment. Furthermore, liquids with acid may cause extensive damage to the finish of these stone products so care must be taken to ensure spill-free storage environment. Warning signs could be posted to alert customers and employees of that risk.

Although proprietary rights (e.g., patents, copyrights, trademarks, licensing, royalty agreements, franchise agreements, or distribution rights) are very important to address in a business feasibility study, this service/product plan does not require it.

Governmental approvals necessary to start the business plan will be identified such as licensing, safety requirements, environmental standards compliance, etc.

Liability is another important aspect to include in this feasibility study. Handling marble, granite, and ceramics is prone to breakage and insurance requirements and costs need to be identified especially when transporting and

delivering the finished products to the customers, (self-insure vs. external insurance policy).

Another aspect of introducing a new product/service in the market is the product/service planning needed to meet the continuously changing market needs in this industry (e.g., service contracts, replacement parts, supplies).

The last aspect, perhaps not the least, is how much will be produced internally and how much of the production will be subcontracted out (name subcontractors and approximate cost of product/service).

The Market

The market analysis is very vital part of the feasibility plan. Some of the concerns that will be addressed in this section are the availability and size of the market for this product and service, the opportunity to prove such market, growth potential, competition, industry trends, customer profile, customer benefits, and market penetration.

If there is no market or the size is not sufficient, it may be useless to continue to pursue this business feasibility plan. The market for the business concept may be so large and obvious that little needs to be done in the feasibility plan other than proving its size. In the business plan much additional market information is required. In the feasibility plan it is enough to prove that a sufficiently large market exists for the concept and, therefore, further investigation of this

opportunity is necessary. The feasibility plans should explain the way the product/service will be sold to the customer and what kind of distribution channels will be used. (John Pappajohn Entrepreneurial Center).

Price and Profitability

In this section, the following topics will be addressed. The customer willingness to pay enough for the product or service to make the business sufficiently profitable so it is worth undertaking; price list; sales estimate; cost of product and service; gross margin; 3-year operating expense and assumptions; 3-year Operating Statement; and start-up costs.

It is vital that the new business maintain a sufficiently high gross margin to cover all of the expenses and still generate an ample profit. The price/cost ratio determines the gross margin. For example, if a customer will pay five times the direct costs, then the gross margin will be 80 percent, since the cost of goods sold will be 20 percent. If sales are one million dollars, then you will have \$800,000 with which to meet expenses and enjoy a healthy profit. (John Pappajohn Entrepreneurial Center).

Supporting Infrastructure

In order for a business to thrive and succeed, there must be some kind of supporting infrastructure such as:

- Financing available
- Supportive government regulation
- Market opportunities

- Access to support services
- Supply of skilled labor
- Connections needed
- Competitive conditions

“Perceived market opportunities, supply of skilled labor, and supportive government regulation relate most consistently to business start-up feasibility and desirability” (Begley et al, 2005). In this section, we will address the availability of these supporting infrastructures in Jordan.

Chapter 2 – “Literature Review”

Jordan Economic Conditions

Jordan has a great potential for business and investment depending on the type of business to be started. According to the World Fact Book, Jordan’s GDP composition is 3.7% in the agriculture sector, 29.9% in the industry sector, and 66.5% in the services sector. These estimates are based on 2009 studies.

Although the waterjet fabrication plant is considered a business in the industry sector, it might also be considered a business in the services sector as the waterjet plant will be providing custom services in the construction products arena.

The industry sector has been growing in strength especially after King Abdullah II of Jordan has implemented “significant economic reforms, such as opening the trade regime, privatizing state-owned companies, and eliminating most fuel subsidies, which in the past few years have spurred economic growth by attracting foreign investment and creating some jobs.” (The World Fact, 2010).

Investors and business entrepreneurs have great access to the Jordanian market as shown below by the number of national and international treaties Jordan has signed with its neighbors and the world.

Investor can benefit from the huge opportunities afforded by the following agreements that were signed by Jordan regionally and internationally:

- Jordan's accession to the World Trade Organization (WTO).
- Jordan's membership in the Greater Arab Free Commercial Area that includes 18 Arab countries.
- Free Trade Agreement between Jordan and the United States of America.
- Partnership Agreement between Jordan and the European Union.
- Trade Agreement between Jordan and European Free Trade Association.
- Privileges Trade Agreement between Member Countries of the Organization of the Islamic Conference.
- Free Trade Agreement with Singapore.
- Accumulation of Origin Agadir Agreement.
- Qualified Industrial Zones (QIZ) Agreement.
- Granting QIZ products the privilege of entering European markets without restrictions or customs.
- Free Trade Agreement between Jordan and Canada

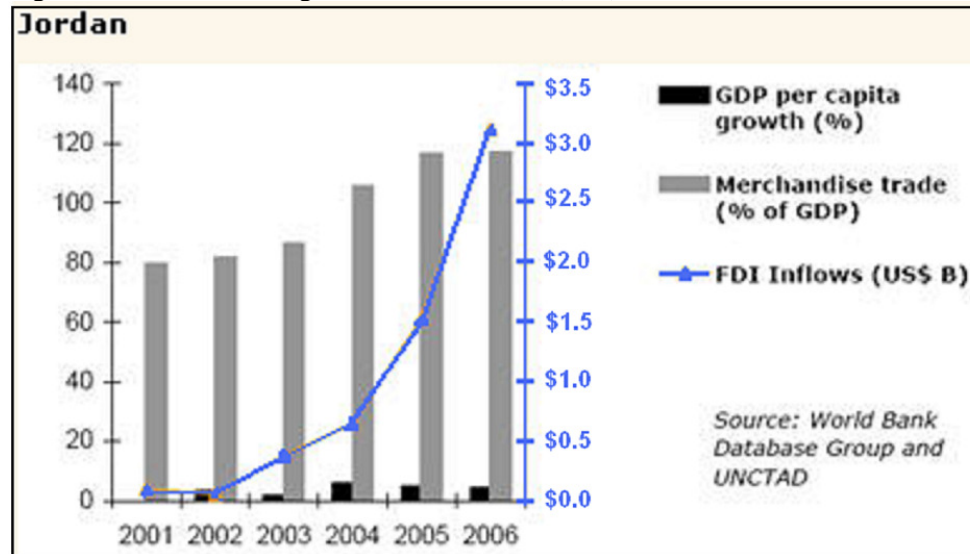
(Jordan Industrial Estates Corporation, 2009)

With a Gross Domestic Product (GDP) (purchasing power parity) of \$30.76 billion Dollars, Jordan ranks in the 104th position compared to other countries in

the world – total of 227 countries - with the European Union being number one and the United States being number two. (The World Fact, 2010)

Although the per capita figures based on 2009 estimates is “\$5,300” (The Word Fact, 2010), there is a significant volume of government and foreign investments pouring into the Jordanian market. Figure-1 below shows the Foreign Direct Investments (FDI) inflows in Jordan between 2001 and 2006.

Figure 1. GDP and Foreign Direct Investment (FDI) in Jordan



Source: FDI.net (FDI Inflows color is modified for print clarity)

Also, according to Jordan Investment Board (JIB) ⁹, a large number of infrastructure and industrial development projects are currently underway in the Middle East region, with an estimated value of \$1 trillion. Both residential (75%) and commercial (25%) markets are growing within Jordan’s construction sector with growth rates in the next 5 years being forecasted to exceed 20% per annum due to growing population, migration, and businesses.

Rising demands in construction projects can be seen in expanding and upgrading infrastructure across the Kingdom such as: mega-real estate projects, transport (rail, airports, and port), municipality developments (Amman Master Plan, Salt Master Plan), Red Sea to Dead Sea Canal and many more.

Furthermore, Jordan is home to many of the raw materials used in constructions which reduce additional expenditure related to transportation of these materials from abroad. “Jordan possesses significant mineral resources used in the construction industry such as building and ornamental stones (including marble), cement raw materials, sand, gravel, crushed stone and natural sand and others. As for building Stones, extensive production is focused on limestone of Cenomanian, Turonian, Santonian, and Eocene ages. These limestones possess desirable properties of good quality dimension stone, uniform in color and texture, free from pyrite, iron oxides, chert, and quartz, low porosity and permeability, and adequate strength.” (Jordan Investment Board, 2008)

Culture and Religion

Culture and religion play a major role in conducting business in Jordan and in the Middle East. To successfully start and operate a business in that region, the entrepreneur must have basic knowledge in the culture and religion of that region simply because the majority of customers are Muslims. In general, Muslims manifest their religion in their daily lives affairs and conduct with others. It is easy for a business man who is not

familiar with the religion and culture to lose a business transaction due to ignorance and having said the wrong thing unintentionally or done the wrong gesture with a potential customer.

John L. Esposito, a world-renowned scholar on Islam, political Islam, and the impact of Islamic movements in Africa and Asia was interviewed by Jennifer Robison of the Gallop Management Journal on July 13, 2006 to address the topic of doing business in the Islamic world. Esposito was asked to explain how valuable is it to know religious traditions if you're doing business in a Muslim country.

Esposito's answer was "If you really want to get involved in a broad-based way in a Muslim country, eventually, you'll have to hire local people. Your own employees will be functioning and living there, too. So, if you're going to work with people in a country, you ought to know them better, but you also want to make sure that you don't offend or screw up. You want to understand ahead of time, and have your employees understand ahead of time, how the culture functions. Religion is a marker in people's identity in many parts of the Muslim world, and it does play a role in society and politics. Clearly you need training sessions."

In addition, Esposito says "Western businesses have much to gain by learning more about the Muslim world's religion and culture."

When Esposito was asked what should executives know before starting business relationships in Muslim countries? His answer was "In many Muslim countries --

again, not all, as we're generalizing about them – most people like to deal with foreigners who really have an interest in the culture, history, language, and faith of the country they're in. But if they're meeting with someone who demonstrates in many ways that he's uncomfortable in their culture, it will be hard for them to connect with him. Now, many people like it when businesspeople ask questions; if they don't, that's an issue. On the other hand, if all of the questions are basic, it can have a negative effect. People feel more confident when they're dealing with somebody who is interested enough and respects them enough to take the time to learn about the country, the culture, and the person. By the way, the role of religion in society has become so important today that you need to be sensitive to it. If you don't know the religion, culture, and society, you can mean well but say things that seem so ignorant that they can be offensive.”

Due to the importance of this survey, a full copy of it is included in Appendix B.

Rules and Regulations

According to the Jordan Investment Board, the government has long recognized the need for establishing business-enabling structures with strong investment incentives. The major aim is developing effective regulatory framework that activates the role of the private sector, increases the volume of domestic investment, and attracts inward international investment. A wide-ranging legislative package has been drafted and introduced to foster a more efficient and transparent business environment.

The Jordan Investment Board further lists the main laws regulating investment related issues in Jordan as shown in Table 1.

Table 1. Investment Environment Regulation Laws in Jordan

Major laws regulating the business and investment environment in Jordan	
Investment law No.68 of 2003	The Privatization Law No. 25 of 2000
Investment Promotion Law No. 67 of 2003	Enterprise Development Law No 71 of 2003
Electronic Transactions Law No. 85 of 2001	The Standards and Metrology Law No. 22 of 2000
Securities Law No. 76 of 2002	Company Law No. 22 of 1997
Trade Secretes and Unfair Competition Law No.15 of 2000	Commercial Agents and Intermediates Law No.28 of 2001
The Industry and Trade Law No. 18 of 1998	The Import and Export Law No. 21 of 2001
Sales Tax Law No. 6 of 1994	The Banks Law No.28 of 2000
Professional Licenses Law No. 28 of 1999	The National Production Protection Law No. 21 of 2004
Arbitration Law No. 31 of 2001	Competition Law No. 33 for 2004
Law of Leasing and Selling Immovable Properties to Non-Jordanians and juristic personsNo.24 of 2002	The Law for Endorsing the United Nations Agreement for Anti Corruption No. 28 of 2004
Free Zones Corporation Law No. 32 of 1984	Credit Information Law No. 82 of 2003
Custom Law No.20 of 1998	Social Security Law No.19 of 2001
Income Tax Law No. 57 of 1985	Labor Law No. 8 of 1996
Environment Protection Law No.52 of 2006.	

Source: Jordan Investment Board

Furthermore, the Jordan Investment Board states that Business Ventures are regulated and governed by several laws and regulations including the Law of Commerce No. 16 of 1966 Commercial law No 12 of 1996 (the code), the **Companies Law No.22 of 1997** and amendments thereto (the '**Companies Law**'), and the **Investment Promotion Law** No. 16 of 1995 (the 'Promotion Law')

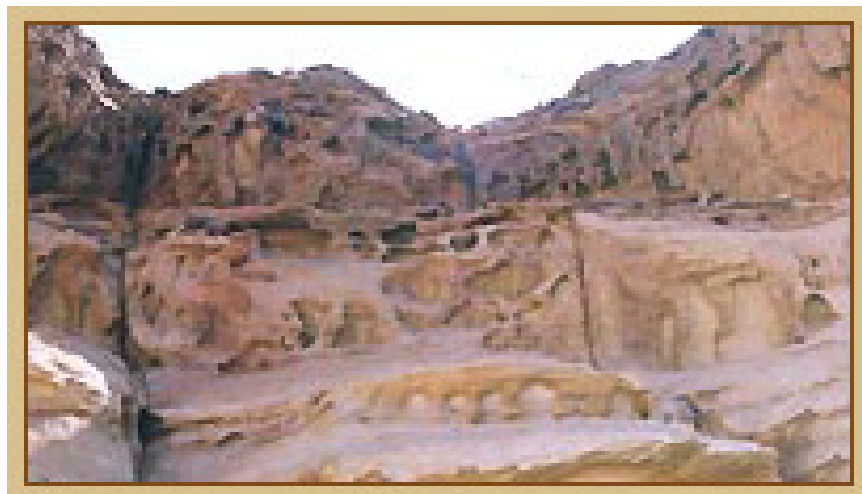
and the **Non-Jordanian Investment Promotion Law Regulation** issued pursuant to the Promotion Law (The 'Regulations').

There are many laws that regulate companies, labor, taxation, customs, intellectual property, and the environment. Full descriptions of these laws are listed in Appendix C.

Constructions Materials and Products

Jordan is home to many of the construction materials used in the construction business of residential, commercial, and industrial properties. “Jordan possesses significant mineral resources used in the construction industry such as building and ornamental stones (including marble), cement raw materials, sand, gravel, crushed stone and natural sand and others.” (Jordan Investment Board, 2008). See sample quarry site images in Jordan shown in figures 2 through 5.

Figure 2. Sand, Gravel, Crushed Stones Site in Jordan



Source: Natural Resources Authority (NRA, 2007)

According to Jordan Natural Resources Authority (NRA), Granite is an igneous rock that consists of feldspar, hornblende, quartz and mica. “The Arabian Shield, consisting of Precambrian crystalline igneous rocks, extends to the Southern parts of Jordan and forms its basement. The rocks were affected by several deformation phases, which resulted in intense fracturing and deep weathering. Intense erosion has left very wide Wadis and Mud Flats, exposing, at the same time, the granites least affected by Tectonism. Through the ages, the basement has been peneplaned and covered by thick deposits of Cambrian and Ordovician rocks.” (NRA, 2007)

Figure 3. Granite Rock Formation Site in Jordan



Source: Jordan Natural Resources Authority (NRA, 2007)

According to NRA, there are three deposits sites, with different granites, located in the South of Jordan. “Reserves within the studied areas are unlimited.” (NRA, 2007).

In addition, rock deposits and formations for marble exist in Jordan. “Marble, is thermo-metamorphosed fully recrystallized limestone, consists of semi-crystallized green, brown, dark violet and black color. The main deposits occur in

strata bound lenses and irregular bodies within the bituminous facies in the upper part of the Chalk-Marl Unit, of Maestrichtian to Danian age and exposed in areas of up to 20 km².” (NRA, 2007)

According to NRA, The occurrences are found in an area between Daba’a and Qatrana, 50 km to 90 km South of Amman, in the following areas:

- West of Daba’a.
- East of Daba’a.
- South of Siwaqa to Khusheim Maatruk.

Roman pillars, East of Daba’a (Tulul El Hammam).

- El Assad quarries.

Five prevailing colors types are distinguished:

- Green
- Brown with greenish tint
- Brown
- Violet
- Black

Reserves within studied areas

- West of Daba’a types (D and E) 60,000 m³
- East of Daba’a total 130,000 m³ and type (B) 32,000 m³
- West Tulul El Hammam total 120,000 m³ and type (B) 12,500 m³
- Tulul El Hammam total 260,000 m³ and type (B) 45,000 m³

- Roman pillars total 60,000 m³
- South of Siwaqa total 560,000 m³ and type (B) 135,000 m³
- El Assad type (D) 225,000 m³ and type (B) 75,000 m³

Marble is used heavily in the finishing façade of the residential, commercial, and industrial buildings. It is used in floors, wall panels, windows and doors decorations, shelves, mosaics, plates, vases, and some times in ornamental ceilings.

In addition, ceramics and granites are also used in the constructions business. Ceramics are used extensively in the walls and ceilings of bathrooms and laundry rooms. Granite on the other hand is used mainly in kitchen countertops and cabinets. However, marble, granites, and ceramics are all used in ornamental designs and landscapes.

In the building stones arena, “extensive production is focused on limestone of Cenomanian, Turonian, Santonian, and Eocene ages. These limestone’s possess desirable properties of good quality dimension stone, uniform in color and texture, free from pyrite, ironoxides, chert, and quartz, low porosity and permeability, and adequate strength.” (Jordan Investment Board, 2008).

Figure 4. Building Stones Site in Jordan



Source: Natural Resources Authority (NRA, 2007)

In the cement raw materials arena, “limestones for Portland cement are widely available in Jordan; the reserves are practically unlimited.” (Jordan Investment Board, 2008). Sand, gravel, crushed stones are also available in abundance. Natural Sand: Reserves are considered to be unlimited for all the above materials.” (Jordan Investment Board, 2008).

Figure 5. Cement Raw Materials



Source: Natural Resources Authority (NRA, 2007)

According to Jordan Investment Board, there are 4,677 industrial facilities located throughout Jordan as industrial clusters. They produce almost all materials used in the construction field.

The proximity of these construction raw materials should provide transportation savings which will be reflected in the price of the finished products. Consequently, the transportation savings could possibly provide a competitive advantage against Italian and Spanish tiles. In addition, it will speed the availability of raw materials to the proposed waterjet plant and, as a result, will speed the order delivery time to the customers.

There are many local companies that produce marble, granite, and ceramics, tiles for construction use. However, there are many imported styles and shapes of tiles that are imported from Syria, Egypt, Italy, and Spain. The attitudes of the customers are inclined towards Italian and Spanish tiles for their product superiority. However, many of those customers cannot afford to buy the Italian and Spanish tiles for their high prices and end up buying locally made tiles. Never the less “Jordanian exports enjoy a reputation for good quality, reliability, and precision, coupled with good service in Arab markets.” (Jordan Investment Board, 2008).

Quality products not only exist in the tile business but also in other sectors. According to Jordan Investment Board, Jordan has a good reputation regionally

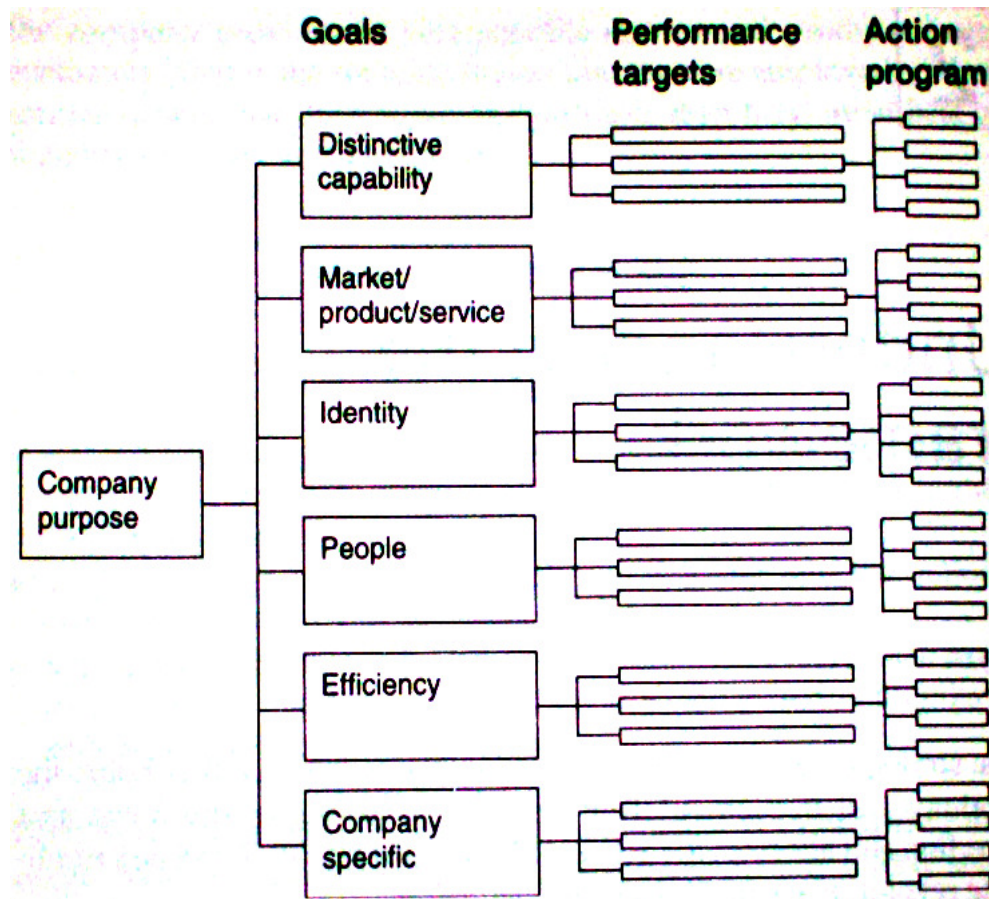
when it comes to working metal and producing metal structures for various construction purposes. Metal manufacturing production increased by 173% between 2000 and 2006, with value added in Jordan increasing by 162% for the same period. Exports reached 485.5 million USD in 2006, contributing 1.7% to the GDP. Major exports were to Iraq and Saudi Arabia. (Workforce 20 K).

Manufacturing includes: pipes, tubes, plates, wires, Iron, steel, aluminum, copper, tin, lead, Nickel/chrome coating, Metal structures, Welding ,Pipe fitting, Painting, Assembly, Installation, Maintenance ,Design, Engineering, Quality Control.

Business Planning

Strategic business planning is very important for the success of any company and will lead to sustainable competitive advantage. In today's business, competition to gain customers and stay profitable in the market is very fierce, and if you are not equipped with a strategic business plan and a clear road map, chances are the business will end up in a state of loss and failure. According to Reading, companies can avoid loss and failure by developing a clear strategic framework and a structured process. A sample strategic business planning framework is shown in figure 6.

Figure 6. Strategic Business Planning Framework



Source: (Reading 2002, 18)

“Strategic business planning (SBP) is the key to developing a business so that it runs effectively and efficiently...It is a process, not a management fad product, based on a proven strategic framework that is effective in setting directions and improving performance for businesses of all types and for divisions and departments within corporations. It incorporates the two fundamentals of strategy, deciding where you want to go and how to implement operational initiatives to take you there, coherently in one process” (Reading 2002, 7)

While strategic planning is very important for the success of companies, Thierauf states even deeper planning and argues that companies need to apply not only strategic planning but also strategic intelligence in corporate planning. He distinguishes between strategic planning and strategic intelligence as follows: “*Strategic planning* is more about breaking down a company’s mission and its objectives into measurable goals. In turn, the expected consequences of these goals are articulated in the form of short- to long range plans and reports that appear in the form of budgets. From this perspective, strategic planning centers on financial measurement and improvement over time... In contrast, *strategic intelligence* centers on understanding the total picture of where the organization is going today and tomorrow. It is an integral part of executive visioning in a changing world. Strategic intelligence is a forward-looking perspective and an articulated vision of the direction that a company should take at the appropriate time and place. As such, it is a guiding force that allows corporate managers the ability to keep their hands on the pulse of the business every step of the way.” (Thierauf 2001, 191-192). A sample effective business intelligence system framework is shown in figure 7.

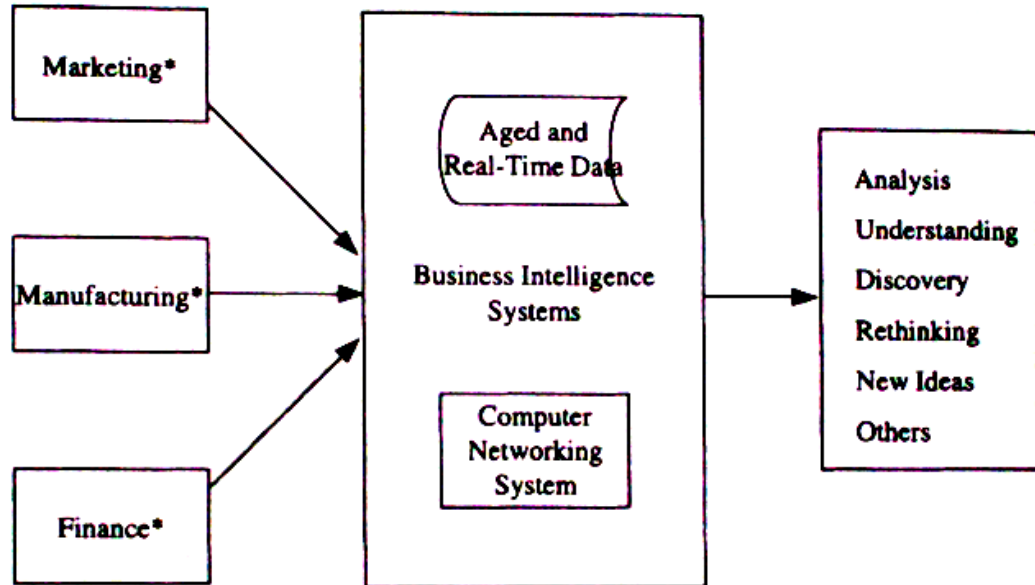
Figure 7. Business Intelligence System Framework

An Effective Business Intelligence System Framework for a Typical Company

**(a) Corporate Planning
Input and Its Operational
Systems**

**(b) Business Intelligence
Software Oversees Processing**

**(c) Resulting Business
Intelligence Output**



* Human Resources are related to each functional area.

Source: (Thierauf 2001, 6)

Both authors, Reading and Thierauf, do agree that strategic planning and strategic intelligence have to address the constant change in the business environment. “A number of leading futurists predict that the 21st century will be times of great change...Several of the driving forces behind these changes are global competition, the continual restructuring of business organizations, the aging of the US populations, continued variations in the inflation (deflation) rate, the volatility of the stock market, globalizations of the capital markets, periodic energy shortages, and accelerating technological changes of all types.” (Thierauf 2001, 191)

While not all the above driving forces affect the economy in Jordan, it is important to recognize that global competition is present and do affect the businesses in Jordan especially after Jordan has opened up their markets to free trade agreements in the early 2000.

Another major aspect of ensuring continued success in the life of businesses is the adoption of quality control through out the cascading levels of the organizations. Perhaps one of the techniques that will promote such quality control is the adoption of the Six Sigma processes and techniques from the very first day of planning to start the company. “Strategic Six Sigma principles and practices have a potentially huge role to play in the planning, building, management, and improvement of quality systems in companies today. Indeed, strategic Six Sigma principle and practices, if employed effectively, can help a company turn its quality systems into a potent marketplace and competitive weapon.” (Smith and Blakeslee 2002, 7)

According to Smith and Blakeslee, Six Sigma is a whole-enterprise strategy of business process management and improvement based on the following four steps:

1. Measuring business and product/service conformance to customer requirements

2. Creating specific continuous actions to reduce variations in existing business processes that cause failures to conform to customer requirements.
3. Creating new innovative products/services and processes to specifically meet customer and market requirements.
4. Repeating steps 1 through 3 continuously as necessary for the enterprise to remain viable and sustain share holder value over the long term

Many companies are incorporating the techniques and principle of Six Sigma into their environment and culture such as GE, Honeywell, Raytheon, and Caterpillar. “A well-known automotive parts supplier in the Midwest is using Strategic Six Sigma practices in conjunction with Lean Manufacturing, Shainin statistical engineering techniques, and DFSS/Robust Engineering approaches to fortify and accelerate its product and process improvement efforts.” (Smith and Blakeslee 2002, 10)

Although the potential company for this feasibility study is not any where compared to the size of these giant companies mentioned above, the company or investor(s) in this feasibility plan should make note of the important role quality systems play in the success and profitability of the new or existing company.

While strategic business planning, strategic business intelligence and quality control systems are core factors in the long term success of business

organizations, it is beyond the scope of this paper to go into details in these areas. However, these topics must be understood and followed clearly to develop a successful business plan. The reader is encouraged to read the cited references in this paper to further gain better understanding in implementing these strategies and quality control systems. However, the brief introduction into business planning presented above should be sufficient for the purpose of this paper.

Chapter 3 – “Procedure and Methodology”

This feasibility study addresses the new product/service to be introduced into the market, the market size, pricing and profitability, supporting infrastructure, and government regulations.

Questionnaires, interviews, and documentation reviews are used to gather and analyze data for this feasibility study. Questionnaires and interviews are used to gather data and answer questions about the product/service and price/profitability. Documentation reviews is used to gather data about the market, supporting infrastructure, and government regulations.

Questionnaires and Interviews

Questionnaires and Interviews are used to collect information about the proposed products and services offered through the waterjet plant as well as information regarding current prices for similar products/services and proposed prices.

The questions regarding the product and services are centered on the capabilities of the waterjet machine to produce precisely cut regular and irregular shaped tiles with smooth and fine edges from marble, granite, and ceramics. These questions allow us to check the possibility of capitalizing on the features of the waterjet machining center to produce top notch tiles that are competitive and perhaps more superior to local and imported tiles. The list of questions is listed below.

1. Are irregular shaped marble, granite, or ceramic tiles currently used in construction arena today?
2. How widely are these irregular shaped tiles used now?
3. How fine are the finished edges of local tiles made with Gang saws?
4. Are there any emerging applications for irregular shaped tiles in the market, i.e. mosaics, floor rosettes, etc.?
5. How do local tiles compare with imported ones?
6. What customers are looking for in a locally produced product to compete with imported ones, i.e. cost, design, quality, raw materials selections?
7. Are local or imported tiles designs and styles continuously available to cover shortages or maintenance needs in existing buildings?

These questions are presented to four experts in the tile business with extensive exposure to the current trends in customer demands and their preferences for tiles. They are also very familiar with the usage patterns of the tiles in the constructions business for the last 30 years. In addition, these tile experts not only deal with customers but also with tile venders and distributors. Their names, length of experience and customer/vendor exposure are listed below.

1. Abdussalam Saleh – 30 years experience and customer/vendor exposure
(Jordan)

2. Ali Hussein – 27 years experience and customer/vendor exposure
(Jordan/Iraq)
3. Fawwaz Hasan – 25 years experience and customer/vendor exposure(Jordan)
4. Ziyad Salim – 24 years experience and customer/vendor exposure
(Jordan/Syria)

In order to get a feel for the current prices of similar products/services and proposed prices, the following questions are developed to present to the same group listed above. The questions are presented in a phone interview. The interview process allows for feedback and discussions with the four subjects. The list of questions proposed during the interview process is shown below.

1. What price will the customer be willing to pay for standard sizes marble tiles?
2. What price will the customer be willing to pay for standard sizes granite tiles?
3. What price will the customer be willing to pay for standard sizes ceramic tiles?
4. What price will the customer be willing to pay for irregular shaped marble tiles?
5. What price will the customer be willing to pay for irregular shaped granite tiles?
6. What price will the customer be willing to pay for irregular shaped ceramics tiles?

7. What price will the customer be willing to pay for cutting services given that the materials are provided by the customer?

Documentation Reviews

Documentation reviews are used to gather information about the market conditions in Jordan, supporting infrastructure for businesses, and government regulations regarding business startups.

The documents used to study these areas are provided by Jordan Investment Board website, Jordan Industrial Estates Corporation materials which includes historical data for the market for the past several years, and Foreign Direct Investment website that contains Foreign Direct Investments data for the Jordanian market. Other documents are used to study business planning like Strategic Business Planning by Reading and Business Intelligence Systems by Thierauf.

Documentation materials from Jordan Natural Resources Authority are used to study the availability of raw materials used in the waterjet plant such as marble, granite, and ceramics. In addition, materials presented in the website waterjets.org are used to lookup information about the waterjet technology and its use in manufacturing.

Chapter 4 - “Results”

Product Analysis

The proposed products comprise of standard size tiles that match in size to those currently available in the market. In addition, the proposed products include irregular shaped tiles according to customer specifications. According to the interviews and questionnaires conducted with the tile laying experts above, there is an increasing demand for irregular shaped tiles made from marble, granite, and ceramics to meet the ever increasing sophistication in architectural facade designs.

Tile mosaics and floor rosettes are commonly used in today’s building decorations. Some designs require irregular shaped tiles of various mixtures of marble, granite, and ceramics, thereby creating a piece of art or an astonishing puzzle.

A waterjet machine is well equipped and capable of producing these shapes in one process. In contrast, existing companies use gang saws to produce regular shaped tiles and diamond wires to produce irregular shaped tiles. Moreover, the products produced by gang saws and diamond wires must undergo two additional processes to smooth out the edges and produce the final product thereby increasing the cost of production.

To successfully compete with imported tiles, the waterjet plant must have access to the same raw materials for marble and granite. According to the expert tile layers interviewed above, imported tiles have more selection of colors and patterns than locally extracted marble and granite slabs.

Marble and granite slabs that compete in quality and color selections with those imported from Spain and Italy might be obtained from other sources such as India, and China provided that prices ensure profitable production in Jordan. Also, it is possible to obtain the marble slabs from Italy and Spain and manufacture the tiles in the plant in Jordan. After all, the labor cost in Jordan is much lower than that in Spain or Italy. The GDP per Capita for Jordan is \$5,300 while for Italy and Spain; they are \$30,200 and \$33,700 respectively. (The World Fact Book, 2010).

The waterjet plant can provide customized cutting services for customers who need special services. The plant could provide the services using commonly used marble, granite, and ceramics materials. Additionally, a customer may provide his own materials for cutting. Such a service will promote excellent customer relations and satisfaction.

Market Analysis

Jordan Investment Board indicated that the current investment in the construction is 1.3 trillion dollars. According to an article written by Ghassan Juha of the Jordan Star, Annual exports of marble and stone is \$35 million dollars which represent 27% of total sales. This indicates that Jordan's annual sale of marble and stone to be around \$130 million dollars. The biggest five companies in Jordan

that provides mass production and distribution of marble, granite, and ceramic products are:

1. Jordan Marble Company
2. Khalifa Company
3. Alkayyali Company
4. Annajah Company
5. Azammar Marble

According to Juha, Jordan's annual exports of marble and stone are estimated at around \$35 million, representing a relatively small market, but a promising one indeed.

”More than 600 registered establishments are currently working in producing marble and stone. These companies employ more than 3300 workers.

Investments in the marble sector are also growing; although no specific figures are available, unconfirmed statistics put these investments at JD 100 million, much of it from foreign businessmen and investors.

Marble quarries cover the Kingdom's landscape. Today these quarries produce hundreds of thousands of square meters of different kinds of marble and stone products. Compared to other countries in the region, Jordan's marble is considered an added-value product. Almost three quarters of the local

production goes to local markets, while the remaining 27 percent goes to the Gulf, Palestine and Italy.

The rapid developments in Jordan's economy over the past few years forced many of the local marble companies to revise their production strategies. It also made them focus on the policies required to make their products more compliant with international standards. The Jordan-US Free Trade Agreement and the Association Agreement with Europe have provided more accessibility to world markets for local marble industries.” (Juha, 2002)

Price Analysis

The first thing in analyzing the price of our product and services is to get a list of current prices for similar products in the market. Table 2 shows the current prices for standard sizes of local marble, granite, and ceramic tiles per squared meter.

Table 2. Standard tile sizes in Jordan

STANDARD SIZES
10 x 10
20 x 20
25 x 25
30 x 30
20 x40
40 x 40
45 x 45

Table 3 shows the current price ranges for standard sizes of imported marble, granite, and ceramic tiles per squared meter.

Table 3. Current tile prices for local and imported tiles

	MARBLE	GRANITE	CERAMICS
LOCAL	\$20-25/m ²	\$60-65/m ²	\$6-7/m ²
IMPORTED	\$50-75/m ²	\$90-120/m ²	\$8-10/m ²

Prices for cutting services vary based on material thickness, length, and type of cut. There were no official prices available for cutting services in the marble, granite, and ceramics tiles. However, according to the subjects of the interview and questionnaires, customer and business can negotiate the price. For our feasibility study, cutting services have to be defined priced well to ensure profitable business transactions.

Sales Estimate

According to Sales Forecasting Forum, “Sales forecasts are common and essential tools used for business planning, marketing, and general management decision making. A sales forecast is a projection of the expected customer demand for products or services at a specific company, for a specific time horizon, and with certain underlying assumptions.” (Reference for Business, 2010).

Sales estimate are usually done using forecasting methods that provide some degree of certainty. Historical sales data improves the accuracy of forecasting. However, when historical sales data are not present, forecasters usually look at market conditions, public sales records of companies selling similar products,

competition in the market to provide the sale forecast, or “conducting an intention-to-buy survey.” (Reference for Business, 2010).

“An intention-to-buy survey measures a target market's plans to buy a product within a given time period. Market analysts frequently conduct such surveys before introducing a new product or service.” (Reference for Business, 2010).

The intention-to-buy survey along with Delphi method, PERT method, and PAM method are referred to as qualitative forecasting methods. According to Reference for Business, “Such qualitative or judgmental methods are often preferred when:

1. The variables influencing buying habits are changing or hard to determine
2. Enough data isn't available to support a statistical approach, [which the case at hand]
3. Quantitative methods have given poor results in this forecasting situation,
4. The planning horizon is too far into the future for normal statistical methods to be useful.
5. There is a need to consider technological breakthroughs which may only be in the early stages of development but will have impact during the forecasting period.”

Conducting sales forecasting using quantitative methods such as “regression,

trend line analysis, exponential smoothing, or moving averages” is not possible within the scope of this study due to lack of historical data. (Mentzer, 1984)

However, once a business plan is completed, it should include a sales forecast. In the mean time I will consider the maximum production capacity of the machine to be the forecasted sale volume. If the true forecasted value is less than the maximum value, production can be reduced to match the forecasted value.

Assuming the machine can be run for 22 hours a day with 2 hours for maintenance, the production capacity for 12”x12” tile is shown in table 3.

Table 3. TALY-3020 Waterjet daily production capacity - one product/day

PSI	Daily Production Capacity			Machine Cost/Tile (Dollars)		
	Marble	Granite	Ceramic	Marble	Granite	Ceramic
44,000	660	660	880	2.00	2.00	2.50
55,000	733	733	1320	2.60	2.60	3.00
Products Demands						
Marble	Granite	Ceramic				
700	700	1000				

Cost of Product/Service

The following table shows the cost for providing the product/service for three years. This includes materials, labor, and any capital expenditures; however, it does not include operating expenses.

Table 4. Cost of providing product/service excluding operating expenses

Item	2011	2012	2013
Materials	\$554,724	\$570,338	\$586,437
Labor(\$5,300/emp)	\$10,600	\$15,900	\$21,200

Taly-3020 Waterjet	\$34,000	\$34,000	\$34,000
Licensing/permits	\$1,325	0.00	0.00
Total	\$600,649	\$620,238	\$641,637

Gross Margin

The gross margin for each product/service for three years is shown in table 5.

“The gross margin is the net sales minus cost of goods sold, sometime called gross profit.” (John Pappajohn Entrepreneurial Center)

Table 5. Gross margin or gross profit

	Marble, Granite, Ceramics		
	2011	2012	2013
Net sales	\$835,380	\$861,277	\$887,976
Cost of goods	\$600,649	\$620,238	\$641,637
Gross margin	\$234,731	\$241,039	\$246,339

Operating Expense and Assumptions

Operating expenses for the new venture for three years includes rent, salaries, office supplies, insurance, and advertising as shown in Table 6.

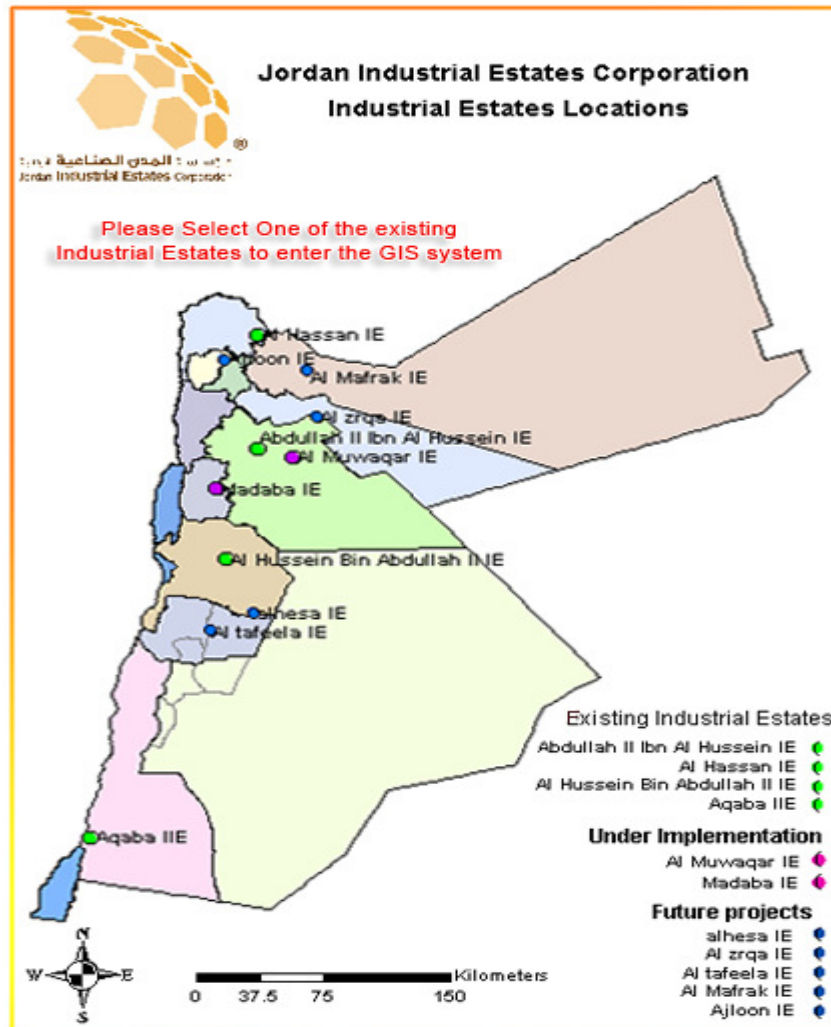
Table 6. Operating expenses for three years

	2011	2012	2013
Rent	\$18,000.00	\$18,306	\$1,8617.00
Salaries^[1]	\$10,600.00	\$10,780.00	\$10,963.00
Office Supplies	\$1,600.00	\$1,627.00	\$1,655.00
Insurance	\$3,000.00	\$3,051.00	\$3,103.00
Advertising^[2]	\$2,000.00	\$2,034.00	\$2,069.00
Utilities	\$3,000.00	\$3,051.00	\$3,103.00
Total	\$38,200.00	\$39,384.00	\$40,605.00

Rent is for a 1000 m² warehouse and 4000 m² in parking space facility provided by Jordan Industrial Estates Corporation. They own several industrial complexes

through out Jordan as shown in figure 8. They provide the necessary infrastructure for the new company, i.e. utilities, communication lines – voice and data, parking, and access to main roads.

Figure 8. Industrial estates locations throughout Jordan



Source: Jordan Industrial Estates Corporation

Three – Year Operating Statement

The operating statement contains the sales estimate, cost of goods, gross margin, operating expenses and profit by year for the next three years as shown in Table 7.

Table 7. Three-year operating statement

	2011	2012	2013
Rent	\$18,000.00	\$18,306	\$18,617
Sales estimate	\$835,380	\$861,277	\$887,976
Cost of goods	\$600,649	\$620,238	\$641,637
Gross margin	\$234,731	\$241,039	\$246,339
Operating expenses	\$38,200	\$39,384	\$40,605
Profit	\$196,531	\$201,655	\$205,734

Start-Up Cost

Startup costs are an estimate of all the start-up expenses for the business such as rent deposit, signage, fixtures, computers, utilities deposits, etc.

Table 8. Startup cost

	2011
Rent Deposit	\$1,800.00
Signage	\$2,000.00
Fixtures	\$8,000.00
Computers	\$3,000.00
Utilities	\$500.00
Total	\$15,300

If the startup costs for the first year are deducted from the profit of the first year, the end result is \$181,231 which is a healthy profit for the new business. It is 34 times the GDP per capita in Jordan.

The waterjet machine can be operated at lower pressure should demands for the products are reduced thus saving cost during operations. I have conducted a sensitivity analysis regarding operating the machine at 44,000 PSI and 55,000 PSI. Full details of the analysis are shown in appendix D.

Chapter 5 – “Suggestions for Additional Work”

The interested reader may find the challenge in pursuing a complete and detailed business plan. The business plan should include a full and detailed market analysis along with marketing plan. In addition, it should explain in details how can the needed capital for starting the new venture be obtained? (Bank, venture capitalist, private placement, friends, relatives, self.) Moreover, the interested candidate should list the key points that should be further researched, such as potential for product and services expansion as the waterjet machines are capable of cutting many types of materials including several types of metals, plastics, glass, composite, cardboard, just to name a few.

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Appendices

Appendix A – Water Jet Technology Overview

Appendix B – Interview w/ John Esposito: Doing Business in the Islamic World

Appendix C – Business and Investment Laws in Jordan

Appendix D – Sensitivity analysis

Appendix E – Taly 30-20 Waterjet Machine Specification

Appendix F – The Management Scientist Model Output

Appendix G – The Management Scientist Validation Model Output

Appendix A - Water Jet Technology (The most complete waterjet resource on the web)

Waterjet is a generic term used to describe equipment that uses a high pressure stream of water for cutting or cleaning purposes. **Abrasivejet** is a subcategory of waterjet in which abrasive is introduced to accelerate the process. **Pure waterjet** and **water-only cutting** are phrases for specifically distinguishing waterjets that do not use abrasive.

In other words: **abrasivejet** and **pure waterjet** are kinds of **waterjet**, and **waterjet** is a kind of machinery.

It is normal, and common, to use the term **waterjet** to refer to **abrasivejets**, though in some cases it can be confusing. On this web site, we'll use **waterjet** when referring to topics that cover both **pure waterjets** and **abrasivejets**, and use the terms **pure waterjet** and **abrasivejet** when discussing topics that are specific to one or the other.

How do waterjets work?

Take ordinary tap water and pressurize it to 60,000 psi (4,000 bar) and force it through a very small hole. Mix the water with garnet abrasive and you have a very thin stream of water traveling very fast that will rapidly erode most materials.

Some waterjets are "pure waterjets" and don't add the garnet abrasive. These are used to cut softer materials, such as food, rubber, and foam.

What can waterjets cut? What can't they cut?

Waterjets can cut just about any material that can be made into a sheet and placed in front of them.

The most popular materials are metals (especially aluminum, because it's relatively soft and cuts quickly), because waterjets can cut intricate shapes to a high precision quickly and economically. Since metals are the most common material cut by machining shops, waterjets tend to cut a lot of metal.

Waterjets also commonly cut stone and glass, because the waterjet can get intricate shapes not possible using traditional machining methods. These materials are popular with artists who like to work with these materials and waterjets because it lets them create almost anything they can envision.

Among the very few materials that waterjets cannot cut are diamonds and tempered glass. Diamonds are too hard to cut (and there may be a few other very

hard materials that can't be cut). Tempered glass will shatter when it is cut with a waterjet (tempered glass is designed to shatter when it's disturbed and is frequently used in windshields for this very reason).

A few advanced ceramics are so hard that it's not economical to cut them. Some composite materials (layers of different materials sandwiched together) can't be cut because the water can seep between the layers and "delaminate" the material. Many composite materials cut just fine, though, and there are some [techniques to cutting laminated materials](#).

What do they cost?

Waterjets typically come as complete systems, including the high-pressure water pump, a system to precisely position the waterjet nozzle, a tank to catch the waste water, and an abrasive feed system. Prices run from \$50,000 to 300,000, with \$150,000 being about average for a mid-range waterjet system.

Prices can run considerably higher than this for custom systems or very large waterjet cutting systems.

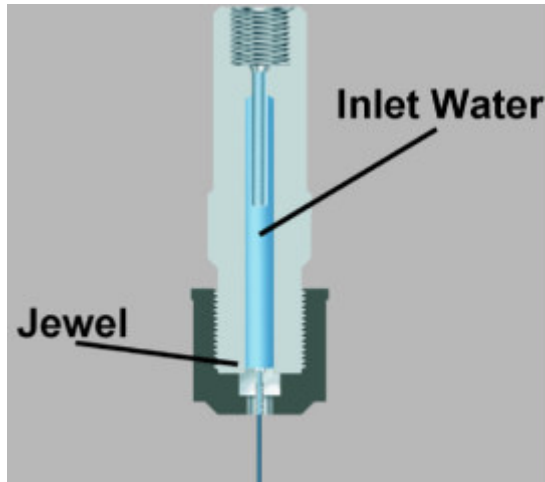
Waterjet systems are not currently something for the home workshop. You'll find them in use in machining shops and industrial workshops. Among other factors, you need industrial levels of electricity to power the pumps (which can pull as much as 50 amps; some pumps require 250 amps to get started).

For the hobbyist interest in waterjets, the more economical approach is to work with a job shop to make the parts. Most job shops can accept computer drawings you create to make exactly the part you want.

Basic waterjet principles

Waterjets are fast, flexible, reasonably precise, and in the last few years have become friendly and easy to use. They use the technology of high-pressure water being forced through a small hole (*typically called the "orifice" or "jewel"*) to concentrate an extreme amount of energy in a small area. The restriction of the tiny orifice creates high pressure and a high-velocity beam, much like putting your finger over the end of a garden hose.

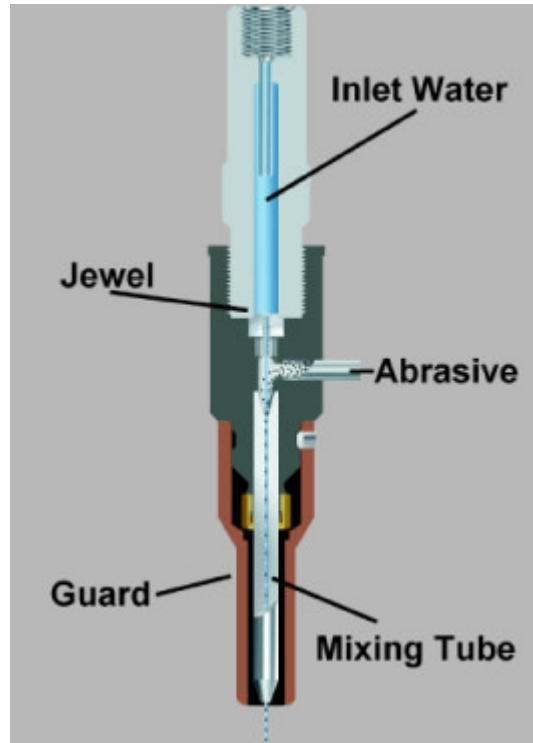
Pure waterjets use the beam of water exiting the orifice to cut soft material like diapers, candy bars, and thin soft wood, but are not effective for cutting harder materials.



Typical design of a pure waterjet nozzle

The inlet water for a pure waterjet is pressurized between 20,000 and 60,000 Pounds per Square Inch (PSI) (1300 to 6200 bar). This is forced through a tiny hole in the jewel, which is typically 0.007" to 0.020" in diameter (0.18 to 0.4 mm). This creates a very high-velocity, very thin beam of water (which is why some people refer to waterjets as "water lasers") traveling as close to the speed of sound (about 600 mph or 960 km/hr).

An abrasivejet starts out the same as a pure waterjet. As the thin stream of water leaves the jewel, however, abrasive is added to the stream and mixed. The high-velocity water exiting the jewel creates a vacuum which pulls abrasive from the abrasive line, which then mixes with the water in the mixing tube. The beam of water accelerates abrasive particles to speeds fast enough to cut through much harder materials.



(Left): A diagram of an abrasivejet nozzle. (Right): Photograph of the same nozzle, with the guard removed, cutting out some parts.

The cutting action of an abrasivejet is two-fold. The force of the water and abrasive erodes the material, even if the jet is stationary (which is how the material is initially pierced). The cutting action is greatly enhanced if the abrasivejet stream is moved across the material and the ideal speed of movement depends on a variety of factors, including the material, the shape of the part, the water pressure and the type of abrasive. Controlling the speed of the abrasivejet nozzle is crucial to efficient and economical machining.

Advantages of waterjet machining

"If you need a machine and don't buy it, then you will ultimately find you have paid for it but don't have it" - *Henry Ford*.

There is a reason that waterjet machining has rapidly grown in popularity since the mid-1990's. Actually there are a number of reasons, listed below, but they mostly come down to "versatility." A waterjet is a versatile and flexible machining tool. You can cut a wide variety of material efficiently and cost-effectively and can create a wide variety of parts.



Machine any two-dimensional shape with one tool

Cut virtually any material

Because waterjets cut using water and abrasive, they can work with a wide variety of materials. These materials include:

- Copper, brass, aluminum:
- Pre-hardened steel
- Mild steel
- Exotic materials such as titanium, Inconel and Hastalloy
- 304 stainless steel
- Brittle materials such as glass, ceramic, quartz, stone.
- Laminated material
- Flammable materials

One of the few materials that cannot be cut with a waterjet is tempered glass. Because tempered glass is under stress, as soon as you begin to cut it, it will shatter into small fragments—as it is designed to do.



Pictured here is a dragon machined from 1" (2.5 cm) thick bulletproof glass, and inlay of marble and granite

Fast setup and programming

With waterjet machining, a flat piece of material is placed on a table and a cutting head moves across the material (although in some custom systems, the material moves past a fixed head). This simplicity means that it's fast and easy to change materials and that no tool changes are required. All materials use the same cutting head, so there is no need to program tool changes or physically qualify multiple tools.

The movement of the machining head is controlled by a computer, which greatly simplifies control of the waterjet. In most cases, "programming" a part means using a **CAD program** to draw the part. When you "push print," the part is made by the waterjet machine. This approach also means that customers can create their own drawings and bring them to a waterjet machine for creation.

Little fixturing for most parts

There are very low sideway forces with waterjet machining--cutting the material doesn't push it. The downward forces are also small, in the range of a few pounds. Typically, the largest force is from the water in the tank pushing back *up* against the material.

Fixturing is generally a matter of weighing down the material by placing weights on it. Small parts might require tabs to prevent them from falling into the tank.

The low side forces, means you can machine a part with walls as thin as 0.01" (0.25 mm). This is one of the factors that make fixturing is so easy. Also, low side forces allow for close nesting of parts, and maximum material usage.

Almost no heat generated on your part

What little heat is generated by the waterjet is absorbed by the water and carried into the catch tank. The material itself experiences almost no change in temperature during machining. During piercing 2" (5 cm) thick steel, temperatures may get as high as 120° F (50° C), but otherwise machining is done at room temperature.

The result is that there is no heat affected zone (HAZ) on the material. The absence of a HAZ means you can machine without hardening the material, generating poisonous fumes, recasting, or warping. You can also machine parts that have already been heat treated.

No mechanical stresses

Waterjet machining does not introduce any stresses into the material.

Machine thick material

While most money will probably be made in thicknesses under 1" (2.5 cm) for steel, it is common to machine up to 4" (10 cm). The thicker the material, the longer it will take to cut. A part made from material twice as thick will take more than twice as long. Some companies make low tolerance parts out of metal that is up to 5" to 10" thick (12.5 cm-25 cm), but it takes a long time and tends to be an occasional operation. Typically, most waterjet parts are made from metal that is 2" (5 cm) or thinner.



Pictured here is a part made from 2" (5 cm) thick 304 stainless steel

Are very safe

Obviously, you don't put any body parts in front of a waterjet machining head while it is on. Anything that can cut through 2" steel will make short work of flesh and bone. Aside from this, however, waterjets are very safe. A leak in a high-pressure water system tends to result in a rapid drop in pressure to safe levels. Water itself is safe and non-explosive and the garnet abrasive is also inert and non-toxic. One of the largest hazards is cuts from the sharp edges of material created by the waterjet.

Modern systems are now very easy to learn

Control of the waterjet head is complicated and requires careful calculation to get the proper speed that will give the best result. This means that the system needs to be controlled by a computer, which means that the user-interface for the system can be simplified and made friendlier. Modern systems are designed the same way as many other computerized CAD systems and are quickly learned.

Environmentally friendly

As long as you are not machining a material that is hazardous, the spent abrasive and waste material become suitable for land fill. The garnet abrasive is inert and can be disposed of with your other trash.

If you are machining lots of lead or other hazardous materials, you will still need to dispose of your waste appropriately, and recycle your water. Keep in mind, however, that very little metal is actually removed in the cutting process. This keeps the environmental impact relatively low, even if you do machine the occasional hazardous material.

In most areas, excess water is simply drained to the sewer. In some areas, water treatment may be necessary prior to draining to sewer. In a few areas, a "closed loop" system that recycles the water may be required.

The pumps do use a considerable amount of electricity, though, so there is some additional environmental (and cost) impact due to this.

No start hole required

Start holes are only required for materials that are difficult or impossible to pierce. A few poorly bonded laminates can fall into this category, in which case pre-drilling or other special methods may be used.

Narrow kerf removes only a small amount of material

The amount of material removed by the waterjet stream is typically about 0.02" (0.5 mm) wide, meaning that very little material is removed. When you are working with expensive material (such as titanium) or hazardous material (such as lead), this can be a significant benefit. It also means that you can get more parts from a given sheet of material.

When machining or roughing out expensive materials such as titanium, your scrap still has value. This is because you get chunks, not chips.

Advantages of waterjets compared with lasers

Laser cutting involves using a laser focused on material to melt, burn, or vaporize the material. The laser can be a gas laser (such as CO₂) or a solid-state laser. The laser beam can be static, and the material moves in front of the laser, or the laser can itself be moved across the material. When the laser moves across the material, additional optics are required as the distance from the emitting end of the laser changes. Lasers have the advantage over traditional machining methods that the laser never touches the material (avoiding contamination) and the HAZ is relatively small.

Waterjets have a number of advantages over lasers. In many respects, however, the two tools are complementary and many machine shops own both of them.

- **Can work with more materials**
Waterjets can machine reflective materials that lasers cannot, such as copper and aluminum. Waterjets cut a wide range of material with no changes in setup required. Also, materials which are heat-sensitive can be cut using waterjets.
- **No heat-affected zone (HAZ) with waterjets**
Waterjet cutting does not heat your part. There is no heat-affected zone (HAZ) or thermal distortion, which can occur with lasers. Waterjets do not change the properties of the material.
- **Waterjets are more environmentally friendly**
Abrasivejets typically use garnet as the abrasive material. Garnet is a non-reactive mineral that is biologically inert. The only issue with waterjets is when you are cutting a material that is potentially hazardous (such as lead), since small pieces of the material will be abraded and mix in with the spent garnet.
- **Waterjets are safer**
There are no noxious fumes, such as vaporized metal, and no risk of fires. The distance between the end of the waterjet nozzle and the material is typically very small, although caution is needed when the waterjet nozzle is raised.
- **Uniformity of material not important**
With lasers, the material needs to be relatively uniform. In particular, when cutting over uneven surfaces, the laser can lose its focus and cutting power. A waterjet will retain much of its cutting power over uneven material. Although the material may deflect the cutting stream, it typically has a negligible effect.
- **Lower capital equipment costs**
The cost of a waterjet machine is generally much lower than that of a laser. For the price of a laser, you can purchase several waterjet machining centers.
- **Better tolerances on thicker parts**
Waterjets offer better tolerances on parts thicker than 0.5" (12 mm). For thinner parts, both waterjets and lasers offer comparable tolerances.
- **Waterjets can machine thicker materials**
How thick you can cut is a function of how long you are willing to wait. Waterjets easily handle 2" (5 cm) steel and 3" (7.6 cm). Although some people have used waterjets at thicknesses of up to 10" (25 cm) in steel, it is difficult to maintain precision in materials thicker than 2" (5 cm). Lasers seem to have a maximum practical cutting thickness of 0.5" (12 mm) to 0.75" (19 mm).
- **Simpler maintenance**
Maintenance on a waterjet is simpler than that of a laser.

- **Simpler operation**

Waterjets are computer controlled, so that the operator does not have to be highly skilled and trained.

- **Better edge finish**

Material cut by waterjets have a fine, sand-blasted surface because of the way the material was abraded, which makes it easier to make a high-quality weld. Material cut by laser tends to have a rougher, scaly edge, which may require additional machining operations to clean up.

Advantages of waterjets compared with EDM

EDM stands for Electrical Discharge Machining and is used to machine electrically conductive materials, such as steel and titanium. An electrical arc rapidly discharges between an electrode and the work piece material. The series of arcs removes metal by melting it and vaporizing it, essentially eroding the metal using electricity. The particles are flushed away by a continuously circulating non-conducting fluid, such as deionized water or kerosene. EDM can create intricate shapes in hard materials that are difficult to machine using traditional methods.



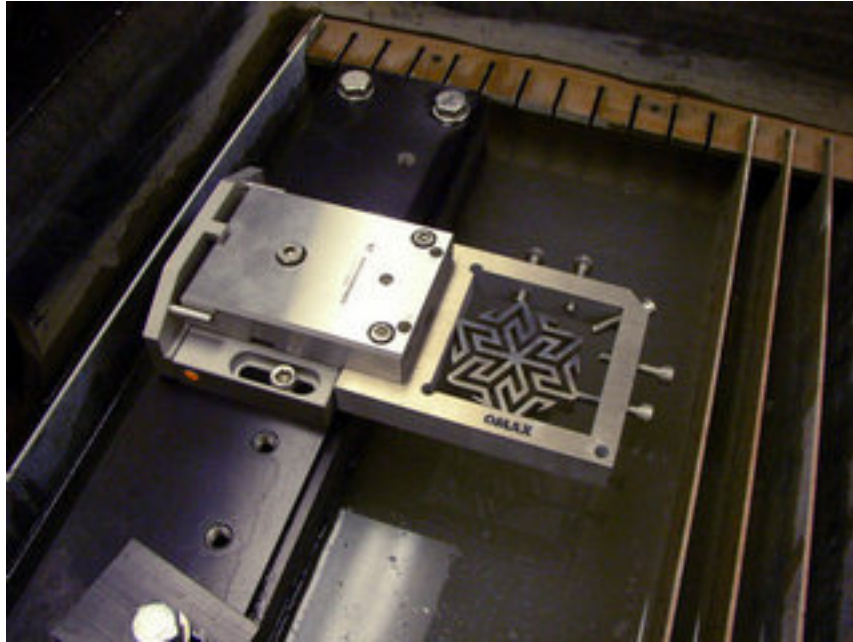
Although the above part could be made using EDM, it's much faster to make it using a waterjet

Many EDM shops are also buying waterjets. Waterjets can be considered to be like super-fast EDM machines with less precision. This means that many parts of the same category that an EDM would do can be done faster and cheaper on an abrasivejet, if the tolerances are not extreme.

New technology allows Abrasive jets to obtain tolerances of up to ± 0.003 " (0.075mm) or better

Abrasive Jet machining is useful for creating start holes for wire insertion later on. (A mill could do the job, but only after spotting the hole, changing tools to drill a pilot, then changing tools again to drill out the hole).

- **Faster**
Abrasive jets are much faster than EDM, which slowly removes the metal.
- **Can work with more materials**
Waterjets can machine non-conductive materials that EDM cannot, such as glass, wood, plastic, and ceramic. There is almost no limit to the type of materials that can be machined with waterjets.
- **Uniformity of material not important**
A waterjet will retain much of its cutting power over uneven material. Although the material may deflect the cutting stream, it typically has a negligible effect. Such material aberrations would cause wire EDM to lose flushing.
- **Waterjets make their own pierce holes**
Some types of EDM, such as wire-cut EDM, a hole needs to be first made in the material, which has to be done in a separate process. Waterjets can pierce the material, requiring no additional fixturing or machining.
- **No heat-affected zone (HAZ) with waterjets**
Waterjet cutting does not heat your part. There is no heat-affected zone (HAZ) or thermal distortion, which can occur with EDM. Waterjets do not change the properties of the material.
- **Waterjets require less setup**
Most of the fixturing with waterjets is weighing down the material so that it does not shift in the water tank. The fixturing needs to withstand forces of pounds and does not need to be elaborate or precise.
- **Make bigger parts**
The size of the part created with a waterjet is limited by the size of the material. In setups where the material passes underneath the waterjet, the finished part size can be huge. Even with an X-Y table setup, part sizes can be quite large.



Wire-cut EDM fixturing in a waterjet machining center. This makes precision fixturing possible. It also allows for pre-machining on the waterjet to release stresses in the material, and then use the exact same fixturing on the EDM to do secondary operations and final cutting to extreme tolerance.



The cheese slicer was made on a waterjet—note the very thin blade

Advantages of waterjets compared with plasma

In plasma cutting, a stream of gas is blown at high speed while an electrical arc is passed through it. This causes some of the gas to become very hot plasma. The gas, at about 27,000° F (15,000° C), then melts the metal or other substance it comes into contact with. The gas is moving fast enough that the molten metal is blown away from the cutting area.

The clearest advantage that waterjets have compared with plasma cutting is that waterjets operate at much lower temperatures. During piercing, the temperature of the material may rise as high as 120° F (50° C), but cutting typically happens at room temperature. The presence of the catch tank (a large tank full of waste water) helps to moderate the temperature as well. This lower temperature means there is no Heat Affected Zone when material is cut with a waterjet.

Waterjets also can cut materials that don't easily melt (such as granite) or that are destroyed by melting (many laminates). Waterjets are also more precise than plasma cutting.

Plasma cutting is typically faster than waterjet, particularly with very thick metal. Plasma torches can pierce and cut steel up to 12" (30 cm) thick.



Modern waterjets machines are relatively clean and quiet

Advantages of waterjets compared with flame cutting

Flame cutting, or oxy-fuel cutting, is used to cut metals by heating them to a high temperature and then introducing oxygen to melt the metal and perform the cut. Flame cutting only is used with iron and steel.

In flame cutting, the cutting torch combines oxygen with a fuel, such as acetylene, that heats up the metal. Once the metal is cherry red, a trigger on the torch is pressed that blasts oxygen at the metal. The hot metal reacts with the oxygen to

form iron oxide (rust), which has a lower metal point than iron or steel. The iron oxide then flows away from the cutting zone. Some iron oxide may remain on the cut as slag, but it is easily removed by tapping or with a grinder.

While flame cutting can work only with iron or steel, waterjets can machine many different types of materials, both metal and non-metallic. Waterjets also do not appreciably heat up the material they cut--during piercing, temperatures may rise to 120° F (50° C), but during cutting the material is heated only a degree or two.

The edge finish created with a waterjet is smooth, similar to a sandblasted finish, rather than the rough edges left by flame cutting. Waterjets are more precise than flame cutting and have a much smaller kerf as less material is removed (particularly important when cutting expensive material).

Flame cutting can be faster than waterjets, especially when done using a multi-torch cutting machine, and as a result is cheaper than waterjet cutting.



The part on the top was roughed out with a waterjet, with secondary machining creating the part shown on the bottom

Advantages of waterjets compared with milling

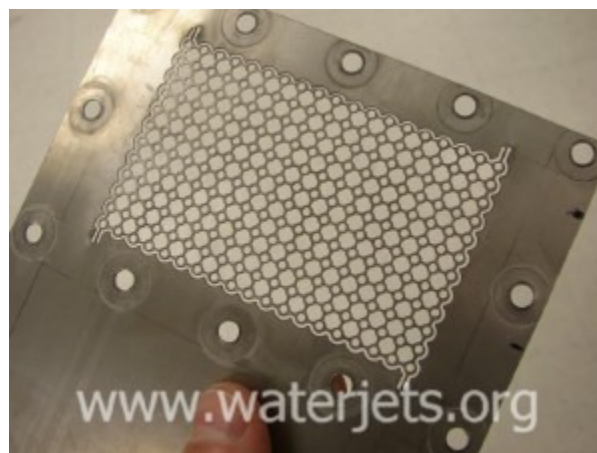
Milling is typically done with a milling machine that can perform a series of operations on material, typically cutting, drilling, lathing, and planing. Most modern milling machines are six-axis machines that can perform complex sequences of milling operations rapidly and precisely.



A typical modern milling machine

Although mills cut faster, in most cases, than waterjets, the setup and fixturing with waterjets is much simpler. Setup with waterjets is typically a matter of just loading the part drawing into the controller software, setting the material and thickness and beginning machining. Similarly, fixturing is mostly a matter of weighing down the material so that it doesn't move on the table during machining. Clean-up on a waterjet is also faster and simpler. As a result, overall, a waterjet can have a greater throughput than a mill on similar parts.

Waterjets can also machine almost any material, including brittle materials, pre-hardened materials, and otherwise difficult materials such as Titanium, Hastalloy, Inconel, SS 304, and hardened tool steel.



With a waterjet, there is also no tool changing. The waterjet nozzle is the only tool used, and it is used for all the different types of materials that a waterjet cuts. There is also less wear on tools, especially in harder and gummier materials, because the cutting action of the waterjet is the stream of water and abrasive. While there is wear on the mixing tube and high-pressure water components, this wear tends to be constant with time, and doesn't change with different materials.

Waterjets are frequently used for complimenting or replacing milling operations. They are used for roughing out parts prior to milling, for replacing milling entirely, or for providing secondary machining on parts that just came off the mill. For this reason, many traditional machine shops are adding waterjet capability to provide a competitive edge.



This is a part you might otherwise do on a mill. It took less than 20 minutes to make with an abrasive jet, including setup and cleanup time! Actual machining time is about 6 minutes. Material is 0.5" (13mm) thick hastalloy with a tolerance about ± 0.002 " (0.05 mm).

Advantages of waterjets compared with punch presses

A punch press uses a set of punches and dies to form parts out of metal. The metal is formed and cut by the punch press into a part, which may have secondary machining done to it or not. Coins are common parts that are formed using punch presses. The typical commercial punch press exerts about 20 tons of pressure.

Waterjets have a lower cost-per-piece for short runs than a die press, because of the expense (and time) involved in creating the dies and punches. Creating the drawing for a part on a waterjet machine is all that's needed to begin machining the part, where with a punch press, the drawing is usually only the first step to creating the die.

Lateral forces with a waterjet are negligible, which means that holes can be placed very close to the material edge, which is not the case with a punch press. Waterjets can also work with very thick materials, while punch presses are limited in thickness to the amount of pressure they can apply. And, of course, waterjets can work with many different types of materials, including brittle and [laminates](#).

Some stamping houses are using waterjets for fast turn-around and rapid prototyping work. Waterjets make a complimentary tool for punch presses because they offer a wider range of capability for similar parts. For high

production of thin sheet-metal, the stamp will be more profitable in many cases, but for short runs, difficult material, and thick material, waterjets have their place.



Five minutes is all it took to make this custom file

Waterjets also play a big part as just one part in a larger manufacturing process. For example, waterjets are often used to machine features into an existing part, or to do pre-machining to remove material before precision finishing on other machinery.

Where waterjets are used

Waterjet machines are not specialty machines for niche applications. They are general purpose tools that are useful in any machine shop. Following is a small sampling of specialized applications.

General purpose machine shops

Waterjets are good all-around machine tools, as it is fast and easy to go from idea to finished part. Waterjets can also work with many different types of materials with minimal fixturing and setup.

Artists

Artists use waterjets because they can create intricate designs in materials that have traditionally been difficult to work with, such as stained glass, marble and stone.

Architectural

Similar to the art market, there are many machines out there making custom flooring from stone, as well as making architectural details from metal

Aerospace

Companies that make parts for the aerospace industry machine lots of aluminum, which is easily machined on a waterjet. Exotic metals such as Inconel[®], titanium, and Hastalloy can also be machined by waterjets.

Manufacturing

Waterjets are used for making parts of products that are sold, as well as many of the parts used to make the machines on the assembly lines.

Automotive & transportation

Prototyping and production parts for automobiles, and the tooling for making automobiles. Also there are a lot of custom race car parts made on waterjets.

Laser shops

Lasers and waterjets are highly complementary tools. They both pick up where the other leaves off.

EDM shops

Some of the small size and higher precision waterjet machining centers are great complementary tools to EDM because they allow for higher speed machining of similar shapes, and can provide other services for the EDM such as pre-drilling start holes or stress relieving the part prior to skim cutting on the EDM.

Model shops / rapid prototyping

Fast turn-around of single piece production in nearly any material makes waterjets great for these kinds of applications.

Schools

Many of the larger size universities that offer engineering classes also have waterjets. They are great tools for the classroom environment because they are easy to learn, program, and operate, and because they can make one-off kind of parts quickly. They also provide a great service to other departments within the university that may need job-shop services.

Looking for somebody to make your part? Check our listings of [waterjet job shops](#).

What it costs to make waterjet parts

There are a variety of ways to calculate the cost of making parts with a waterjet. This is true of most businesses, and the calculation of "Cost of Goods" is the subject of many books and business classes. This page looks at some approaches

to calculating the cost of goods for parts made with a waterjet, which will then help you determine how much to charge for a part.

A lot of people price the work on their machines on dollars per hour basis. This may make sense for some kinds of machines, but not for a waterjet. A job shop with a multi-head machine running two pumps or a high power pump might have a much higher cost of operation than a shop with a small machine with a low power pump. If these two shops compete against each other purely on dollars per hour, then the shop with the smaller cheaper machine will make a lot more money. This is because the parts will take longer to make, and they will be cheaper to make, so the customer pays more yet the part costs less to make. The shop with the faster machine must therefore charge more per hour to take advantage of their faster machine.



A waterjet machine with four heads (Photo courtesy Pegasus Northwest, Inc.)

Another strategy is to price the work based on a dollars per square inch basis. This has the drawback that a part with a lot of geometry to it (curves and corners and pierces) will take a much longer time than a straight line cut, because the waterjet must slow down to avoid **blow-out** at the corners and turns. Likewise, material thickness and many other factors come into play, and cutting speed is not a linear function relating to thickness. So, while \$/square inch may make sense for some machines, it does not for waterjets.

The best approach is to figure out how much it will cost you to make the part. Then estimate how much it would cost to make the part by competitive methods (either other kinds of machines, or your competitor with an waterjet). See if there are other savings such as being able to squeeze more parts from expensive material. Then, price from there. Your customer does not need to know if you are charging them \$100per hour. They are not paying you for your time, they are paying your for the part.

Another option that can work, if you prefer a simpler, more objective formula, is to simply cost your work based on your true cost to make the part. Many

machines have software built in to make this easy. Simply take the cost to make the part, and multiply by a factor, and there you have it.

The cost to make your part should include the following factors:

- How much time will it take to program the path into a tool path? (And if the customer provides the toolpath in a compatible file format, any price break you might choose to give them.)
- How much risk is there that you might break something (such as when cutting glass) and need to scrap it and start over?
- Does the customer provide the material, or do you need to purchase the material?
- How many times must you pierce the material? Each pierce is extra wear and tear on machine, and the associated risk of a nozzle plug or material cracking during piercing.
- How much do your consumables cost you?
 - Electricity
 - Water
 - Abrasive
 - Spares and wear parts
- Is there any special setup or risk to consider?
- How much time will it take to actually do the cutting?
- How much time will it take you to load and unload the parts and material, and clean up the machine afterwards?
- Is the customer ordering a large quantity?
- Is this taking your machine away from doing another possibly more profitable job?

Typical price ranges

Prices range up to \$2000.00 per hour for some parts, but \$100 to \$135 per hour is more typical, and it can be as low as \$80/hour. You should look at the part to machine, and think of what it would cost on a mill, or other competing equipment. Then price the part slightly under that, and make a good profit. However, pricing and pricing strategies are highly dependant on local market conditions.

Appendix B - A GMJ Q&A with John L. Esposito (Robison, Jennifer - 2006)

Recently, Gallup published the Gallup Poll of the Muslim World, a follow-up survey to its polling in the region in 2001. The results give us a view into the minds of Muslims from Mecca to Marrakesh, and pack a few surprises: Majorities in many of the predominantly Muslim countries surveyed support women's rights to vote, drive, and work. In addition, Muslims in each of the countries most often mention the West's political freedom and technological advances as what they admire most about the West.

John L. Esposito, Ph.D., is one of the few people who isn't surprised by what the Muslim world has to say. Dr. Esposito is a university professor and a professor of religion and international affairs and of Islamic studies at Georgetown University and the founding director of Georgetown's Prince Alwaleed Bin Talal Center for Muslim-Christian Understanding in the Walsh School of Foreign Service. He is also the past president of the Middle East Studies Association of North America and of the American Council for the Study of Islamic Societies and a consultant to governments and multinational corporations. He is editor in chief of the Oxford Encyclopedia of the Modern Islamic World, and his more than 35 books include *What Everyone Needs to Know About Islam* and *Unholy War: Terror in the Name of Islam*. Dr. Esposito is coauthor of the forthcoming book, *Can You Hear Me? Listening to the Voices of a Billion Muslims*.

The findings from the Gallup Poll of the Muslim World are surprising and occasionally contrary to Western assumptions. This research has had enormous political and social impact; it can also be incredibly valuable to business. Though Islam is quintessentially business-friendly -- the Quran makes numerous references to commerce and business ethics -- entrée into the Muslim business world is tricky. The rules of the game are not so different, but the culture is, and few Westerners understand it. In this, the first part of a two-part series, Dr. Esposito discusses what the West has gotten wrong about the East and vice versa, what pioneering Western business leaders have learned from their travels in the Middle East, how to socialize in a dry country, and what to do to close the deal.

GMJ: *What has the West gotten wrong about Islam?*

Dr. Esposito: That it is a violent religion.

GMJ: *Where do you think Westerners get that idea?*

Esposito: Well, because Muslims commit acts of violence. Christians commit acts of violence, and Jews commit acts of violence, but we distinguish very carefully between extremists and the mainstream in Christianity and Judaism. I think that often the magnitude of global terrorism and the rhetoric of terrorists like Osama bin Laden, their so-called "Islamic rhetoric," leads people to think this must be what their religion is all about. So for many Westerners, their engagement with Islam is through the acts of extremists.

Westerners were able to make distinctions when, for example, a Jewish fundamentalist killed Yitzhak Rabin or a Christian bombed an abortion clinic, because we have a context within which to place it. Until the Iranian revolution, Islam was not on most Americans' cognitive maps. We weren't conscious or aware of it.

GMJ: *But the terrorists are still setting the context for many people, including those who would like to do business in Muslim countries.*

Esposito: I've been doing consulting with companies for a long time, and years ago, many companies felt no need to be aware of this part of the world. Some companies that worked in the region had orientation sessions, but they were primarily business-related, and they didn't really get into the religion and culture. In America, the attitude is often, "I do business with you, and it doesn't matter what your religion is." Well, that works until there's a crisis, and then suddenly, a businessperson's asking, "What are these people really like? Are they really a threat to my country? Are they ultimately a threat to my company?" And many people in Muslim countries whom Westerners dealt with were very westernized, or at least came across as very westernized.

Westerners interacted with a very small section of the business population, a very secular elite. But you can no longer assume that someone who seems very Western isn't also a very, very devout Muslim.

GMJ: *How valuable is it to know religious traditions if you're doing business in a Muslim country?*

Esposito: If you really want to get involved in a broad-based way in a Muslim country, eventually, you'll have to hire local people. Your own employees will be functioning and living there, too. So, if you're going to work with people in a country, you ought to know them better, but you also want to make sure that you don't offend or screw up. You want to understand ahead of time, and have your employees understand ahead of time, how the culture functions. Religion is a marker in people's identity in many parts of the Muslim world, and it does play a role in society and politics. Clearly you need training sessions.

GMJ: *Oil companies were pioneers in doing business in the modern Middle East. What can we learn from them?*

Esposito: A while back, oil companies that did business overseas realized that they needed to put more into understanding religion and culture. One reason is because they would bring local employees to the United States for training, but the oil companies could be training them for jobs that many of them would regard as jobs that you hire foreigners to do, not educated people like themselves. So they would come over for the training session, but when they went back home, they weren't happy in the level of job. The oil companies were operating out of an American mentality, thinking, "Well, we're a good company; we're giving them a good entry-level job -- or one close to it -- and they can fast track." But in their culture, if you have an education, and if you're at this stage of work, you don't start in an entry-level position. And it was insulting. That's not something you understand unless you know the culture.

I remember talking to a CEO whose oil company was operating in a Muslim country. Everything was fine when he was at work, but when he would give a social at night, almost nobody would show up. There were all kinds of cultural reasons for this, including the way the social was organized, whether or not alcohol would be served, and also how Americans and America was viewed. It's one thing to work with Americans; it's another thing to socialize with them. He had to learn a lot, fast.

Good training deals with everything, including the political, religious, and cultural situation of the country you will be working in. You need it when you make decisions about expanding your business, what kind of folks you'll hire, and what you should be aware of in terms of the workplace.

GMJ: *But you're not saying people need to have a deep comprehension of Islam.*

Esposito: I think they need to understand the basic faith of the people. But remember, there are big cultural differences among Muslim countries. In today's environment, you certainly can do business in lots of countries, but in many parts of the Muslim world, religion and identity are being expressed more in society. So if you want to be able to make crucial decisions about where you'll work, how much you'll invest in a place, if you want to have your own employees interacting with a variety of segments of society, it's important to understand the diversity among the people you'll be dealing with. It's not just enough to know that you'll be dealing with a small group of, let's say, highly Westernized secular elites -- you need to be aware of what I call "alternative elites."

Many members of parliament or businesspeople are professionally oriented, but they also take their religion very seriously. You need understand that, both for damage control and for productive reasons. You want to be able to relate to them and get along with them better and form good relationships with them.

GMJ: What should executives know before starting business relationships in Muslim countries?

Esposito: In many Muslim countries -- again, not all, as we're generalizing about them -- most people like to deal with foreigners who really have an interest in the culture, history, language, and faith of the country they're in. But if they're meeting with someone who demonstrates in many ways that he's uncomfortable in their culture, it will be hard for them to connect with him.

Now, many people like it when businesspeople ask questions; if they don't, that's an issue. On the other hand, if all of the questions are basic, it can have a negative effect. People feel more confident when they're dealing with somebody who is interested enough and respects them enough to take the time to learn about the country, the culture, and the person. By the way, the role of religion in society has become so important today that you need to be sensitive to it. If you don't know the religion, culture, and society, you can mean well but say things that seem so ignorant that they can be offensive.

GMJ: How do Westerners offend?

Esposito: If Westerners demonstrate that they don't have a clue about the basic beliefs of a people, this can be seen as offensive. So can suggesting that Islam is more violent than other religions. So can being less than respectful about dress or modernity. In some societies, covering your head is not simply a sign of being traditional; many modern-minded Muslims don't want to wear Western dress. Tactless observations can be offensive even to people who don't dress that way or think that way. You could be working with somebody who's very secular minded and very Westernized, you go out and knock down the Johnny Walker Reds together, and you can make all kinds of judgments from this. But if you start ridiculing or knocking their religion and culture, then you're ridiculing their identity.

GMJ: What about those Johnnie Walkers? How does business socializing work when you can't buy someone a drink?

Esposito: Businesspeople often go out of their way to create social situations that involve going out for drinks, or playing golf together, or that involve theater or music. But there are other ways to socialize, and you need to socialize. In many parts of the world, it's important to go beyond just the formal relationship to establish a personal connection. Well, this is *really* important in many parts of the Muslim world. Not just in the Muslim

world, but in many parts of the world, the personal dimension becomes really important; it enhances somebody's willingness or ability to do business with you.

GMJ: How does that work specifically?

Esposito: There are lots of things that people do, but it seems to me that the most important thing to do is establish a human connection. For example, Americans and Europeans are willing to do business simply on the basis of business. They expect to move pretty quickly on something based on phone calls, on maybe one quick visit, or after just an exchange of letters and e-mails. In many Muslim societies, people like to really get to know the person they're going to do business with. I know some very, very prominent people in the Arab and Muslim world who, before they make a final decision, will have wanted a number of visits. They do their due diligence of course, but part of the way they do that is by meeting the top management of the company they'll be partnering with.

I dealt with this with some corporate people who communicated the idea that, "I want to do a deal with you, so I'll have somebody lay some groundwork. Then I'll fly across the world, we'll sit down for an hour or two, we'll talk, we'll do the deal, and I'll leave." Well, they could do that, but if the person they're doing business with is as powerful as they are, or even more so, he'll expect them to spend more time and show more interest. It's not like he needs what they have so desperately that he's going to be simply delighted when they come in to give him a signature. Unless they know that the person they're doing business with likes to operate that way, it's too much of a slam-bam approach.

It's important to realize that. If they have a sense of the culture and the people that they're dealing with, then they can fast track with them.

-- Interviewed by Jennifer Robison

Appendix C – Business and Investment Laws in Jordan (Jordan Investment Board, 2008)

Company Law

Company Law is vital for a successful business environment. It remains important because it determines the environment in which investors will be operating their businesses in. The Company Law No. 22 of 1997 limits routine procedures and facilitates the process of company registration. The Law introduced the not-for-profit company form as well as the civil company form, which provides for the establishment of companies by professional persons, such as lawyers, doctors or engineers. Under the new Law, companies are no longer required to pay a 15 percent capitalization charge, which had previously proved a barrier to capital reserves. In addition, amendments to the Law allow company founders to adopt the prices they deem appropriate in estimating the value of their fixed assets. One should understand the nature of companies and their registration procedures in order to measure their effects on the economy. It is also important to note that significant developments have been made in the administration and procedures of registration within the Ministry of Industry and Trade (MIT). And more reform is underway.

The following information regarding company law is classified into three main parts. The first part explains the **nature of companies** according to the Jordanian law. The second part discusses the **major types of companies with a financial tincture** in Jordan. The third part is dedicated to **partnership**. In this regard it should be noted that a joint venture need not be registered in Jordan and, hence, is not governed by the Company Law. A joint venture is typically regulated by the contractual agreement between the joint venture parties. This does not apply in the event that the parties envisage the establishment of a corporate entity.

The nature of the company to be registered must be defined. This is accomplished by specifying both the type and class of company.

Under the Jordanian Company Law different types of companies offer different advantages and have different requirements and conditions for both registration and operation. The following are the types of companies, definitions, and registration procedures:

Partnership

Limited Liability

Limited Liability in Shares

Public Shareholding

Private Shareholding Companies

Foreign Company

Types of a company according to Financial Tinctures: Within each company “type”, the “class” of company must also be specified. Each class of company has its own set of conditions. The classes of company permissible by law are as follows:

- Regular
- Civil
- Offshore
- Non-Profit

Investment Promotion Law No. (16) of 1995

The different laws in Jordan recognize the benefits that foreign direct investment will bring and include provisions that encourage domestic entrepreneurs as well. Jordan targets the following sectors for favorable tax and custom duty treatment: industry, agriculture, hotels, hospitals, maritime transport and railways, leisure and recreational compounds, convention and exhibition centers, transporting & distributing water, gas & oil, call and contact centers, research and development to benefit from the following:

Freedom from custom duties:

- Fixed assets are exempted from fees and taxes provided that they are imported into the Kingdom for the use of the project exclusively. These assets include: the machinery, equipment and supplies used in the project including furniture and equipment for hotels and hospitals.
- Imported spare parts for the project shall be exempted from fees and taxes provided that their value does not exceed 15% of the value of the fixed assets for which they are required.
- Fixed assets required for the expansion, development and modernization of the project shall be exempted from fees and taxes if such expansion, development or modernization shall result in an increase in the production capacity of the project by no less than 25%
- Hotel and hospital projects shall be granted exemption from fees and taxes once every seven years for the purchase of furniture and supplies required for modernization and renewal
- Any increase in the value of fixed assets which are imported for the project shall be exempted from fees and taxes, if such an increase is a result of a rise in the price of such assets in the country of origin, a rise in freight charges applicable thereto, or of changes in exchange rate.

Exemptions from Taxes:

Corporate income tax rates in Jordan are as follows

- 15% on mining, industry, hotels and hospitals
- 35% on insurance and financial institutions

- 25% on all other companies
- 0% on agriculture projects

The Kingdom is divided, for the purpose of granting the above-mentioned exemptions, into three development areas: A, B and C. Projects in these areas shall enjoy exemptions from income and social services taxes for a period of ten years starting from the date of commencement of work for services projects and the commencement of production for manufacturing projects, according to the following percentages:

- 25% if the project is in a class A development area
- 50% if the project is in a class B development area
- 75% if the project is in a class C development area

Investment Guarantees

- The different laws governing investment in Jordan offer equal treatment to both Jordanian and non-Jordanian investors, thus allowing the non-Jordanian investor to own any project in full or part, or to engage in any economic activity in the Kingdom, with the exception of some trade and contracting services which require a Jordanian partner.
- Except for participation in public shareholding companies, the non-Jordanian investment may not be less than fifty thousand Jordanian Dinars (JD 50.000 or \$ 70.000)
- The investor has the right to manage the project in the manner he/she deems appropriate, and through the person(s) chosen by the investor for this purpose.
- The non-Jordanian investor shall be entitled to remit abroad without delay, and in a convertible currency, the invested capital together with any returns and profits accrued, the proceeds of liquidation of the investments as well as the proceeds of the sale of all or part of the project.
- Non-Jordanian technicians and administrators working in any project may transfer their salaries and remuneration abroad.
- It shall not be permissible to expropriate any project or to subject it to any equivalent measures, unless such expropriation is done for a purpose which is in the public interest and in return of a just compensation. The amount of compensation for non-Jordanian investors shall be made in convertible currency.
- Investment disputes between an investor of foreign capital and Jordanian governmental agencies shall be settled amicably. If no amicable settlement can be reached within a period not exceeding six months, either party may resort to litigation or may refer the dispute to the International Center for the Settlement of Investment Disputes (ICSID)
- Any investor, whose investment is guaranteed by his country or by an official agency thereof, may assign to that country or agency any returns on his investment or other compensation to which he is entitled.
- With approval of the Incentives Committee, the investor may re-export the exempted fixed assets.
- With approval of the Incentives Committee, the investor may sell the exempted fixed assets or relinquish them to another investor or project not

covered by the provisions of this law after paying the fees and taxes due on such fixed assets.

Labor Law and Policy

Labor is the driving force of any successful business and labor Legislation aims at facilitating the efficient use of labor, Jordan's current labor laws and policies are examined below.

Labor Legislation

In Jordan, the legal framework organizing labor is mainly comprised of the Jordanian Labor Law of 1996 and its amendments. This Code repeals the Labor Code of 1960, and all amendments made thereto. It governs labor affairs in Jordan. The provisions of the law apply to all employees and employers as defined by Article 2 of the Law. This law was completed by regulations, instructions and decisions issued in accordance with its provisions. Based on ratified conventions, amendments to the labor law were adopted in 2002. These amendments concern some important provisions, mainly:

- The extension of the coverage of the labor law to some categories of workers in the agriculture sector;
- The establishment of private employment offices organizing the recruitment of foreign domestic workers, and control of these offices by labor inspectors. This will extend the control of the Ministry of Labor in dealing with the recruitment and working conditions of these workers;
- The protection of workers from dismissal due to economic and technical factors by adoption of detailed regulation;
- The regulation of working hours;
- The inter-relation between employers' and workers' organizations
- Other laws, regulations, instructions and orders that affect the labor environment in Jordan include:

 - Regulation No. 23 of 1966, as amended, issuing rules governing the public service, defines individual labor relations, paid leave, compensation, temporary assignment and termination of service;
 - The Maritime Law of 1972 which governs maritime employment (seafarers contract of employment, advance payment withholding and authorized remittance of seafarers wages);
 - Order of the Minister of Labor to establish committees to study the cases of termination or suspension of contracts of employment on the basis of the

provisions of section 31 of the Labor Law. This Order establishes committees in each governorate where there is a Directorate for work and employment, so as to study the cases of termination of contracts of employment for undetermined periods or cases of suspending such contracts for economic or technical reasons;

- Regulations No. 36 of 1997 concerning work permit fees for non-Jordanian workers, issued under Article 12 of the Labor Code of 1996. This Act provides for the fees to be paid by the employer for the delivery of work permits;
- Regulations No. 56 of 1996 concerning labor inspection, promulgated under Article 7 of the Labor Code;
- Industrial accidents and occupational diseases instructions of 1993; instructions issued by the Social Security Authority which prescribe the procedures to be observed in the event of such an accident, and provide for medical assistance to victims and financial compensation for disability resulting from an industrial accident or the contraction of an occupational disease;
- Social Security Law No. 19 of 2001. This law provides for the establishment of the General Social Security Institution, which should provide social insurance for all workers under sixteen with certain exceptions (seafarers, domestic servants, agricultural workers). It deals also with labor injuries and occupational diseases, old age, disability and death benefits.

While other legislation exists, the Labor Law organizes most subjects related to the labor environment. Employment is governed as well by an employment contract, which is drawn in Arabic with two copies produced; if no such contract is made, the worker may establish his rights by all legal means of evidence. The duration of the employment contract is set by agreement of the parties. If the worker is employed for an indefinite duration, he shall be considered in service until his employment is terminated in accordance with the provisions of the Law.

Intellectual Properties Law (IPR)

IPR is considered as a powerful tool for economic growth in many sectors. For example, intellectual property reforms in Jordan have greatly benefited the country's economy in general and its pharmaceutical sector in particular. Jordan's pharmaceutical sector has gained new export markets and has started to engage in innovative research as a result. New health sectors, such as contract clinical research, have emerged, and health-sector employment has grown as well.

Laws are consistent with the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) now protect trade secrets, plant varieties, and semiconductor chip designs in Jordan. Registration of copyrights, patents, and trademarks is required. Copyrights are registered at the National Library and

patents are registered with the Registrar of Patents and Trademarks, which is part of Jordan's Ministry of Industry and Trade. Jordan has signed the Patent Cooperation Treaty and the protocol relating to the Madrid Agreement concerning the registration of marks, but ratification was still pending in early 2005. Jordan has also acceded to the World Intellectual Property Organization (WIPO) treaties on copyrights (WCT) and performances and phonograms (WPPT).

Table-2 Intellectual Property Laws in Jordan

IP laws in Jordan	
Patent Law No. 32 of 1999 and its amendments.	The Law of Unfair Competition and Trade Secrets No. 15 of 2000
Trademarks law No. 33 of 1952 and its amendments.	The Geographical Indications Law No. 8 of 2000.
The Protection of layout designs of Integrated Circuits No. 10 of 2000	Copyright Law No 22 of 1992 and its Amendments
The Industrial Designs and Models Law No. 14 of 2000	The Protection of New varieties of Plants Law No. 24 of 2000
Goods Marks Law No. 19 of 1953	Trade Names Law No. 22 of 2003

Source: Jordan Investment Board

Competition Law

Competition plays a major role in developing the business environment. The importance of competition is derived from the fact that it is mainly based on market freedom which is vital for the growth of businesses.

The legislative activities related to competition are the promulgation of two laws. The first is the Unfair **Competition and Trade Secrets Law No. 15 of 2000**, the second being the **Competition Law No.33 of 2004**. The Competition Directorate within the MIT is responsible for the implementation of the Competition Laws and ensuring that all commercial practices are consistent with its provisions.

Environmental Law and Policy

Jordanian policy makers are aware of the environmental dimension in the business climate. Although environmental concerns might not affect all economic activities, it still remains important to bear in mind concerns regarding the appropriateness of certain investments as they regard environmental policy.

Currently there are a set of laws and regulations that govern environmental

issues: **Environment Protection Law No. 52** of 2006 is the primary legislation that organizes the environmental issues in Jordan. There are other regulations that organize specified areas such as water protection, air protection, nature protection and environmental impact.

Appendix D – Sensitivity analysis

Background

My business plan calls for a fabrication center initially equipped with one Taly-3020 water jet machine. Complete specifications of the machine are provided in Appendix E. Although the machine is capable of cutting many types of materials including stainless, copper, brass, glass, plastics and many others, my initial decision is to cut marble, granite, and ceramics since the demands for them is high in that region compared to the others.

The machine is setup to run for 22 hours with two hours maintenance on a daily basis and two weeks yearly maintenance. The production schedule is set up to cut marble for one day, granite for the next day and ceramic for the third day and so on. The common standard size of 12”x12” per tile is selected for production to maximize profits since the size is commonly used in constructions in Jordan.

The daily production capacities of the machine when run at 44,000 PSI are 660 marble tiles, 660 granite tiles, and 880 ceramic tiles. At 55,000 PSI, the daily production capacities are 733 marble tiles, 733 granite tiles, and 1320 ceramic tiles.

The demands for the marble, granite, and ceramic tiles are 700, 700, and 1200 tiles respectively.

Problem Definition

The new fabrication center goal is to meet the production demands at the lowest cost. The machine cost per tile at 44,000 PSI is \$2.00 for both marble and granite while it is \$2.50 for ceramics. At 55,000 PSI, the cost per tile is \$2.60 for both marble and granite while it is \$3.00 for ceramics. Running the machine at higher pump pressure requires more energy and thus additional cost. The machine can be operated at 44,000 PSI or 55,000 PSI. The problem facing the new fabrication center is to meet production demands at the lowest cost.

I have developed a model to help us decide what water jet pressure the machine need to operate on to produce and meet the client demands for marble, granite, and ceramic. The model is stated as follows based on the table of data below:

	Daily Production Capacity			Cost/Tile (Dollars)		
PSI	Marble	Granite	Ceramic	Marble	Granite	Ceramic
44,000	660	660	880	2.00	2.00	2.50
55,000	733	733	1320	2.60	2.60	3.00

Products Demands		
Marble	Granite	Ceramic
700	700	1000

LET: ML \equiv Number of marble tiles produced at 44,000 PSI
 GL \equiv Number of granite tiles produced at 44,000 PSI
 CL \equiv Number of ceramic tiles produced at 44,000 PSI
 MH \equiv Number of marble tiles produced at 55,000 PSI
 GH \equiv Number of granite tiles produced at 55,000 PSI
 CH \equiv Number of ceramic tiles produced at 55,000 PSI
 L \equiv Binary (1= run machine at 44,000 PSI)
 H \equiv Binary (1= run machine at 55,000 PSI)

O.F.: MIN $2ML + 2GL + 2.5CL + 2.6MH + 2.6GH + 3.0CH$ (Minimum cost of prod.)

S.T.: ML - 660L ≤ 0 (machine capacity for marble at 44,000 PSI)
 GL - 660L ≤ 0 (machine capacity for granite at 44,000 PSI)
 CL - 880L ≤ 0 (machine capacity for ceramic at 44,000 PSI)
 MH - 733H ≤ 0 (machine capacity for marble at 55,000 PSI)
 GH - 733H ≤ 0 (machine capacity for granite at 55,000 PSI)
 CH - 1320H ≤ 0 (machine capacity for ceramic at 55,000 PSI)
 ML + MH = 700 (demand for marble)
 GL + GH = 700 (demand for granite)
 CL + CH = 1000 (demand for ceramic)
 L + H = 1 BINARY (Practical)

Based on the TMSv6 solution, the machine should be operated at 55,000 PSI to meet the client demands. The minimum cost is \$6,640.00. The full TMSv6 output of the model is shown in Appendix F.

Sensitivity Analysis

According to the model, the machine is operated at 55,000 PSI and thus can meet and exceed the client's demands. Constraints 4 through 6 indicates that there is unused capacity to produce 33 tiles of marble, 33 tiles of granite, and 320 tiles of ceramic.

Model Validation

I changed the demands for the marble, granite, and ceramics to 600, 600, and 800 respectively and ran the model again. The model suggested running the machine at 44,000 PSI to produce the required demands at the lowest cost. The results came out as expected since the new demands are within the machine capacity at 44,000 PSI. The new cost is \$4,400.00. In addition, the validation model gave the correct sensitivity information about the unused machine capacity when demands for marble, granite, and ceramics were changed to 600, 600, and 800 respectively. The unused machine capacities for marble, granite, and ceramics are 60, 60, and 80 tiles as shown in the validation model.

The full output of the TMSv6 validation model is given in Appendix G.

Appendix E – Machine Specifications

Water Jet (TALY-3020) Specifications

No.	Name	Data	Unit
	Prices	\$105,000 \$96,000	US dollar
1	Type	4.0×2.0 (HY380) 3.0×2.0 (HY380)	
2	Maximum Cutting Range	158" × 78" 118" × 78"	inch
3	Travel of Knife Rest	0-8"	inch
4	Driving Speed Servo Motor	0-480	inch/min
5	Cutting Accuracy	±0.20 (0.005")	mm
6	Controlling accuracy	±0.01 (0.00025")	mm
7	Working Motor	Servo Motor	
8	Air Compressor Pressure	0.6-0.8	MPa
9	Abrasive	Garnet	
10	abrasive granularity	60-100	Item
11	Microcomputer	686	
12	Program Software	SAME's Waterjet Scanning Program System	

FIVE AXIS head

YH-380 (supercharger)

No.	Name	Data		Unit
		HJ300	HY380	
1	Adjusting Range of Cutting Pressure	0-300	0-380 (0-55,000psi)	Mpa
2	Working Pressure	180-250	330-380	Mpa
3	Maximum Water	2	3.7	L/min

	Flux				
4	Water Nozzle (Stone)Diameter	Ø0.25-Ø0.3		mm	
5	Inner Hole Size of Sand-Mixed Pipe	Ø0.8 or Ø1.0		mm	
6	Mainframe Motor	Type	Y225S-8	Y225-4	
		Rating Power	18.5	37 (50HP)	Kw
		Rating Rotating Speed	726	1480	r/min

CUTTING PARAMETER

Material	Thickness (inch)	Cutting speed (working pressure 300Mpa) 44,000 Psi (inch/min)	Cutting speed (working pressure 380Mpa) 55,000 Psi (inch/min)
Stainless steel	3/8"	12"	16"
	1 1/4"	4"	8"
	1 1/2"	2"	3 1/4"
	2"	3/4"	1 1/4"
brass	1 1/4"	48"	60"
	2"	40"	34"
Aluminum	3/8"	32"	40"
	3/4"	20"	24"
	1 1/4"	12"	16"
	2 3/4"	3 1/4"	4"
Marble	3/4"	28"	32"
	1 1/4"	16"	20"
	2"	4"	6"
Granite	3/4"	28"	32"
	1 1/4"	4"	16"

	2"	2"	3 1/4"
	4"	3/8"	3/4"
ceramic	3/8"	40"	60"
	2"	16"	24"
Glass	3/8"	40"	48"
	3/4"	24"	32"
	1 1/4"	20"	24"
	2"	8"	12"
Laminated glass	3/4"	24"	32"
foam	3/4"	80"	120"
	2"	40"	60"

Appendix F – TMSv6 Output

INTEGER LINEAR PROGRAMMING PROBLEM

MIN $2ML+2GL+2.5CL+2.6MH+2.6GH+3CH$

S.T.

- 1) $1ML-660L<0$
- 2) $1GL-660L<0$
- 3) $1CL-880L<0$
- 4) $1MH-733H<0$
- 5) $1GH-733H<0$
- 6) $1CH-1320H<0$
- 7) $1ML+1MH=700$
- 8) $1GL+1GH=700$
- 9) $1CL+1CH=1000$
- 10) $1L+1H=1$

OPTIMAL SOLUTION

Objective Function Value = 6640.000

Variable	Value
ML	0.000
GL	0.000
CL	0.000
MH	700.000
GH	700.000
CH	1000.000
L	0.000
H	1.000

Constraint	Slack/Surplus
1	0.000
2	0.000
3	0.000
4	33.000
5	33.000
6	320.000
7	0.000
8	0.000
9	0.000
10	0.000

Appendix G – TMSv6 Output for the Validation Model

INTEGER LINEAR PROGRAMMING PROBLEM

MIN 2ML+2GL+2.5CL+2.6MH+2.6GH+3CH

S.T.

- 1) 1ML-660L<0
- 2) 1GL-660L<0
- 3) 1CL-880L<0
- 4) 1MH-733H<0
- 5) 1GH-733H<0
- 6) 1CH-1320H<0
- 7) 1ML+1MH=600
- 8) 1GL+1GH=600
- 9) 1CL+1CH=800
- 10) 1L+1H=1

OPTIMAL SOLUTION

Objective Function Value = 4400.000

Variable	Value
ML	600.000
GL	600.000
CL	800.000
MH	0.000
GH	0.000
CH	0.000
L	1.000
H	0.000

Constraint	Slack/Surplus
1	60.000
2	60.000
3	80.000
4	0.000
5	0.000
6	0.000
7	0.000
8	0.000
9	0.000
10	0.000