

**Tantalum Wire Product Development Strategy –
Gaining a Competitive Advantage in a Commodity Market**

by

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In Partial Fulfillment of the Requirements for the Degrees of

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And

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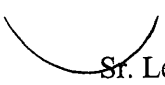
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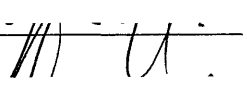


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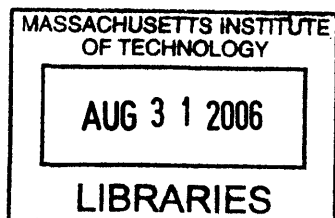
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BARKER

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ABSTRACT

In the face of growing competition and the commoditization in the Tantalum Wire business, H.C. Starck must find a way to differentiate their wire products from competitors in order to survive in this market.

This thesis studies the possibility of developing a new product into the market by launching a product development process, with the goal of gaining a competitive advantage and sustaining it, thus increasing profitability over time. For this purpose a decision support model was developed to analyze the economical and operational feasibility of a new product. All aspects of launching a new product development process in H.C. Starck Wire department were modeled to simulate uncertainties across the Tantalum supply-chain, and recommendations were drawn based on results.

A number of goals were addressed in this study: First, a robust link was created between the scientific potential and the economical potential of a new wire development. Second, a recommended strategy was defined for H.C. Starck Wire department in order to differentiate their products in lieu of low cost competition.

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This thesis is dedicated to my son Ron, who was born two days after I completed writing it and in a way witnessed the internship and the thesis development 'from the inside'.

Pursuing higher education is a life long tradition in my family - a tradition that had an influence on me throughout my career. My parents have always treated education as a basis to any successful career and my grandfather, Yehezkel Lieder, proved that it is never too late to go back to school. I am therefore following in the footsteps of my family and I am thankful for it.

Lastly and most importantly - there is no way I could have been a part of the MIT Leaders For Manufacturing program and given this great opportunity without the ongoing and unlimited support of my husband Boaz, who with his love and belief in me contributed mostly to the fact that I am pursuing this experience. He is and continues to be my balance and I love him for that.

Michal Hovav
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Chapter 1: INTRODUCTION

1.1 Thesis Objective

The objective of this thesis is to analyze and improve upon the product development process of the next generation Tantalum wire product, which will be designed and manufactured in H.C. Starck Inc. (a wholly owned subsidiary of Bayer Material Science Company) in Newton, Massachusetts. The focus of this analysis is on aligning the product development process with the forecasted financial indicators of this product (i.e. future profitability, capital investment, cost structure etc).

This work is the product of collaboration between H. C. Starck and the Leaders for Manufacturing program at MIT. The data presented in this thesis was collected in the wire manufacturing facility of H. C. Starck in Newton, Massachusetts.

1.2 Problem Statement

H.C. Starck manufactures both Tantalum wire and Tantalum powder, both of which are used in the production of Tantalum Capacitors. The Tantalum wire supply chain includes Tantalum ore mining, Tantalum wire and powder manufacturing (by H.C. Starck), Tantalum capacitors production, and finally the capacitors being used in products such as electronics (cell phones, PDAs), automotive, military and medical products. Since 2000, the Tantalum wire market has operated as a commodity market, where competitors manufacture similar products, competing mostly on price. In order to effectively compete in this market and maintain future profits, H.C Starck needs to gain a competitive advantage that will be sustainable in the face of tough cost competition from China. H.C Starck can utilize its reputation and skill in technology leadership and innovation to develop a new Tantalum wire product that will enable the industry to move to higher-capacitance Tantalum capacitors, in which both Tantalum wire & powder act as components. These capacitors will support the ongoing electronics industry trend of increased miniaturization and speed, as evident in the high growth rates for cell phones, PDAs, wireless products and similar products. There is a significant first mover advantage for such a product, and speed to market should enable a significant market share gain, as well as a price premium advantage. However, product development for the

next generation Tantalum wire product cannot be initiated as an independent process. It has to be directly linked to the **business aspects** of new product development: required capital investments for R&D, potential revenues and profits in years to come, forecasted product sales, and current cost structure. The product development process must also be linked to the **operational aspects** of a new product – available manufacturing capacity on floor, product mix of all wire products, capacity utilization, as well as available labor and other constraints. When facing such a strategic crossroad, H.C. Starck needs to develop a decision support model that will consider multiple ‘what-if’ scenarios and will assist in making informed financial and operational decisions before launching a new product development effort that is both capital and time intensive. Such a model was developed and is described in detail in this thesis. This model supports H.C Starck by providing an ROI & profitability analysis under uncertain market conditions. The model was linked to the new product development process to optimize schedule and cost aspects. In addition to this model, H.C Stack also needs to resolve a technical issue with the new Tantalum wire product. This issue is faced by their customers and is gating the high-volume production and sales of the high capacitance wire/powder combination. Therefore, H.C. Starck will need to evaluate several technology sources within the product development process. While the model developed has focused on Tantalum wire, a comprehensive business case must include both wire and powder.

1.3 Thesis Overview

This thesis has four main sections. Sections 1 and 2 include introductory and background material describing the setting for this research. Section 3 includes a summary of the results achieved, and section 4 provides conclusions and recommendations.

For reasons of confidentiality some data (including volumes, forecasts, etc.) in this thesis has been disguised.

Chapter 2: SETTING AND PROBLEM STATEMENT ANALYSIS

In this chapter the business environment of Tantalum is reviewed, with special emphasis on the Tantalum supply chain and the major market forces influencing it. First, the key players in the Tantalum supply chain are individually introduced and described in the context of their position in the supply chain. Second, a generic framework to assess market attractiveness is reviewed, and third, the entire Tantalum Wire market is assessed for its attractiveness using this framework. This chapter concludes by analyzing different strategic responses the company can execute in order to improve its position within the Tantalum Wire market, and a recommended strategy is offered.

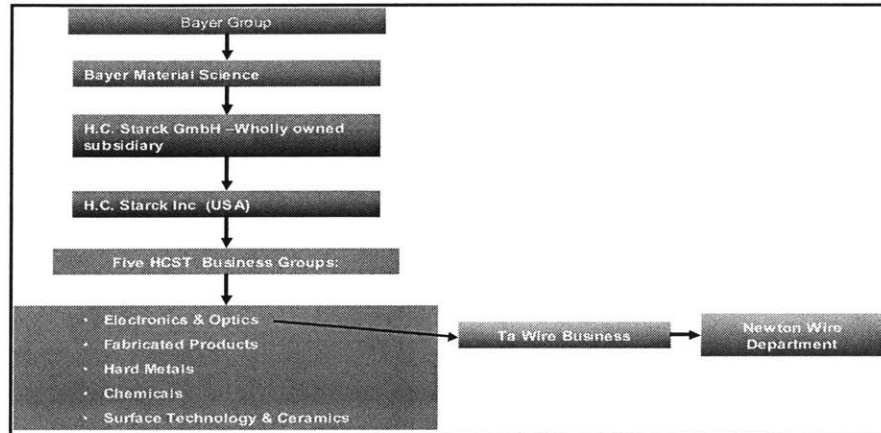
2.1 Setting

The research for this thesis was conducted at the wire manufacturing facility of H. C. Starck Inc. (a wholly owned subsidiary of Bayer Material Science Group) in Newton, Massachusetts, from June through December 2005. Founded by two MIT grads, H.C. Starck (formerly NCR) is a major international producer of Tantalum and Niobium products for the electronic, semiconductor, chemical, pharmaceutical and other specialized industries. Capacitor grade tantalum wire is a critical component in the manufacture of capacitors for the electronics industry. A leader in the global passive electronic components industry since its inception, H.C. Starck has continued to maintain its strong position through its high quality product offerings in challenging applications – applications that continue to shrink their product life cycle and increase their technical complexities due mainly to the boom in electronic applications and distribution.

2.2 Company overview

In the 1980s, H.C. Starck GmbH was purchased by Bayer AG (Germany), and H.C. Starck Inc. became a wholly owned subsidiary of H.C. Starck. The majority of H.C. Starck's production comes from their manufacturing facilities in Germany, Japan and the United States. The company is organized into five different business groups aligned with the industry and customers they serve: Hard Metals (HM), Chemicals and Mill products

(CH), Electronics and Optics (EO), Surface technology and advanced ceramics (OK), and Fabricated Products (FP). Two of these business units operate at the Newton site; Electronics and Optics (EO) and Fabricated Parts (FP). Chart 1 describes H.C Starck’s



organizational structure within Bayer, and the Tantalum Wire department within it:

Chart 1: Bayer and H.C. Starck Organizational Structure

The Newton site also houses a consolidated site services group for plant functions such as Human Resources, Accounting, Engineering, Quality Control and Safety. The EO group is primarily responsible for the production of Tantalum powder and tantalum wire, while the FP group is primarily responsible for the production of fabricated tantalum parts such as alloy additives and sputtering targets. The Newton wire department is responsible for research and development activities as well as the production of Tantalum and Niobium wire. The Newton wire facility is the only wire manufacturing facility at H. C. Starck (i.e. a single source for Tantalum wire). While Tantalum’s end markets are diverse and consist of Tantalum capacitors, military applications, chemical industry and others, the Tantalum wire products are not as diverse and are mostly sold to capacitor manufacturers (more than 90% of total volume) with a small quantity sold to medical implants companies.

2.3 Tantalum

Anders Gustav Ekeberg of Sweden, using an ore sample, discovered tantalum in 1802. He named the newly discovered element after King Tantalus of Phrygia, from the Greek mythology, who was condemned to eternal frustration by standing up to his neck in water

that receded when he tried to drink it. Ekeberg shared King's Tantalus frustration when he tried to isolate Tantalum¹.

Tantalum is a rare metal, gray in color, and possesses several unique characteristics:

- High temperature resistance (melting point: 2996 degrees C)
- Excellent corrosion resistance to most acids & organics
- Has a very high density
- Good conductor of heat & electricity
- Ductile
- Easily fabricated
- Excellent dielectric properties (Tantalum Oxide)

These unique physical properties along with its high cost determine its application.

Its exceptional dielectric properties lead to a very high volumetric efficiency, capacitance and reliability, which make it a good candidate for capacitors. These Tantalum capacitors distinguish themselves from other types of capacitors (i.e. Aluminum and Ceramic) by a very high volumetric efficiency of capacitance (thus their ability to carry a greater capacitance in a smaller device volume), as well as a greater reliability under extreme conditions of stress and temperature (thus they are ideal for automotive applications where 'under-hood' temperatures can cause other capacitors to fail).

Tantalum's corrosion-resistant characteristic, similar to glass, is ideal for chemical processing, and makes it one of the best materials for body implants. Tantalum improves the refractive index of lenses to make them thinner, and it provides X-rays with a brighter image, while reducing the radiation dosage to the patient².

2.4 The Tantalum Business Environment

2.4.1 Tantalum Wire Supply Chain

The Tantalum wire supply chain is relatively long and complex. It originates from Tantalum Ore in a mine and finished in a consumer end product such as a cell phone, a laptop, a PDA or a car. Chart 2 represents a simplified Tantalum wire supply chain. The upcoming section will describe the role of each player in the supply chain in greater detail.

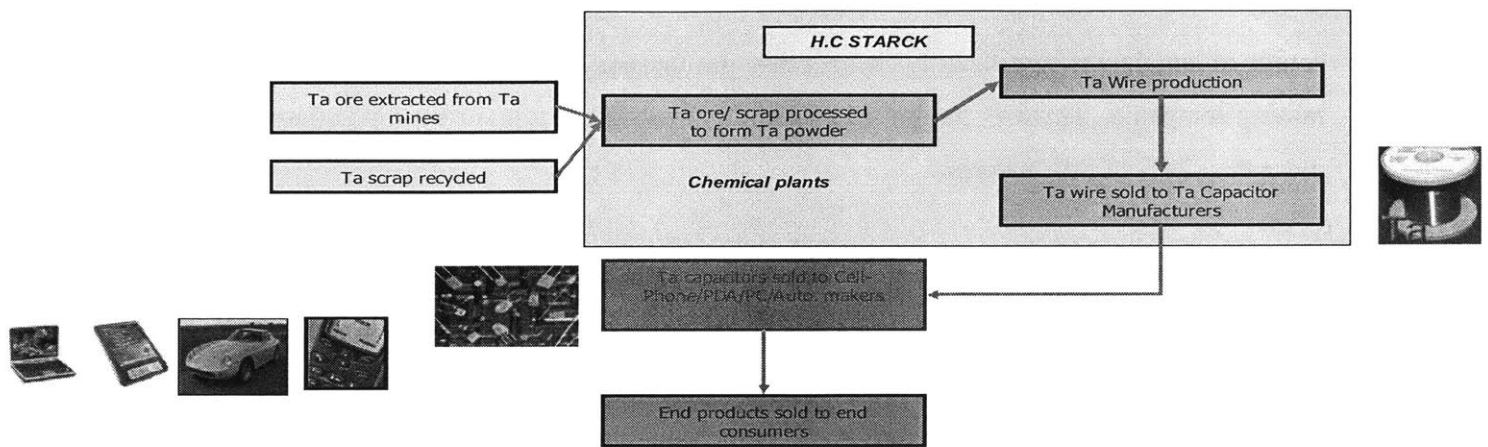


Chart 2: A simplified Tantalum Wire supply chain flow

The following section describes the key players in the Tantalum Wire supply chain, their respective roles and their relative contribution to the entire supply chain complexity. The players are described in the same order as in the supply chain – from the most upstream level (raw material suppliers) to the most downstream level (end customers).

Tantalum ore miners: Mining companies extract the Tantalum minerals that are found in limited locations worldwide, as indicated by chart 3 below. Most Tantalum mines today are of the ‘Hard Rock’ type, which requires a significant capital investment and usually takes two to three years to be brought to market. These companies sell the Tantalum ore to the powder and wire processors (companies like H.C. Starck and others) through long-term ‘take or pay’ contracts³. The largest active mines for Tantalum are hard rock mines in Australia. Chart 3 maps the Tantalum raw material sources:

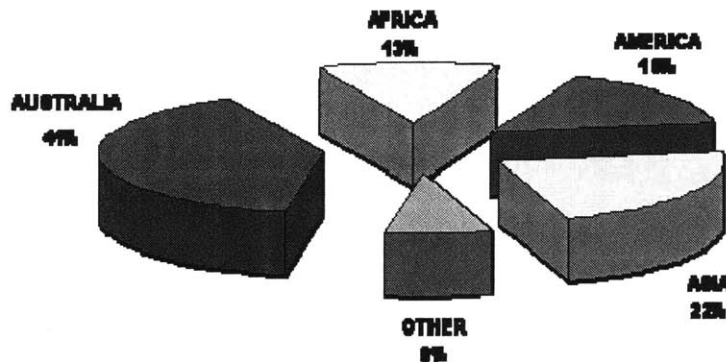


Chart 3: Sources of Tantalum mines worldwide

Nearly 20% of the Tantalum powder and wire source comes from recycled scrap, since the Tantalum scrap recovery during the manufacturing process is close to 100%. This

source of tantalum is significantly cheaper than purchasing Tantalum extracts from the mining companies, however its limited availability prohibits it from being sourced at more than 20% of raw materials.

Between 1999 and 2001, illegal tantalum mining in the Kahuzi-Biega National Park in Africa partially financed the civil war in the Congo. In response to the crisis in the Congo, the U.S. House of Representatives passed a resolution in September 2001 that banned the purchase of tantalum from the Congo. Tantalum's price skyrocketed with a price increase of ten-fold within several months, in the face of distorted news stories about shortages. Slogans like “Blood Tantalum” and “No Blood on my Mobile,” became haunting symbols of the scramble for tantalum among major corporations that locked in astronomically high contract prices for future delivery of the rare metal from legitimate sources. In June 2003, The UN Security Council issued a statement on the “Illegal exploitation of natural resources and others forms of wealth of the Democratic Republic of the Congo.” In that statement, the panel of experts recorded the reactions of individuals, corporations and countries involved in the tantalum business.

Powders and Wire Processors: Companies like H.C. Starck and its competitors purchase the Tantalum ore, concentrate it, refine it into an oxide, convert the oxide into a chemical compound (K_2TaF_7) and then reduce the K_2 to the pure metal form of Tantalum. They manufacture Tantalum powder and wire for multiple end markets, the majority of which is dedicated to Tantalum capacitors, as detailed in chart 4 below:

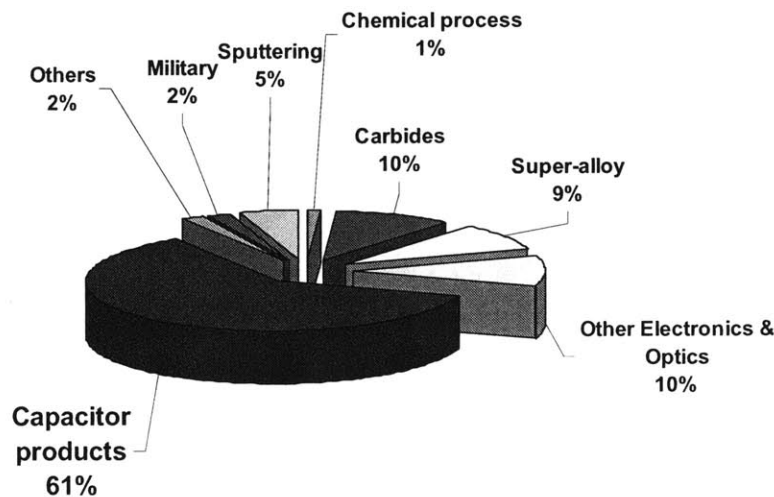


Chart 4: Tantalum end-markets demand per industry

During the late 1990s and early 2000s, the cell phone, communications, Internet and computer markets all witnessed double-digit growth rates (this era was also known as the 'NASDAQ boom' and the 'Dot Com' period). These events had a significant impact on the Tantalum supply chain, as a perceived shortage of Tantalum capacitors was highlighted by the press, and contributed to a surge in Tantalum capacitor prices. This shortage was extremely overestimated. In 2001 the entire tantalum capacitor market collapsed along with the electronics industry, as the market 'discovered' that the actual demand was much lower than had been anticipated and the Tantalum supply chain was left with enormous amounts of excess inventory (from raw materials to finished goods) ⁴.

The market collapse of 2001 began a price war at a level previously unseen in the industry. Unfortunately this effect will probably not fade away. On top of excess inventory in the supply chain, several new Tantalum wire producers from China entered the market post-2001 and contributed to the price war by offering their products below the average market price ⁵. The actions of the Chinese firms resulted from having a lower cost structure as well as a strategic move to gain market share undercutting prices. The Chinese lower cost structure originated from the lower labor rates in China as well as from pursuing a different raw material sourcing strategy - buying raw Tantalum in the open spot-market without the long term contract obligations. This sourcing strategy resulted in a lower raw Tantalum price, however with greater risk due to pricing volatility in the spot market. Chinese companies also purchased raw Tantalum from countries in Africa (mainly Congo) that were boycotted by western companies due to social reasons described above. In order to maintain their level of market share and prevent a loss of their customer base, the non-Chinese incumbents in the Tantalum Wire market responded to the new entrants by matching the lower prices offered by the Chinese firms, thus cutting their own margins significantly. As a result of the price war, the average Tantalum wire selling price (\$/Lb) has been going down consistently since 2000, and is predicted to continue to drop. The price war has placed tremendous pressure on wire producers to reduce cost in ways they had not faced before. Chart 5 demonstrates the trend in Tantalum wire selling price over time.

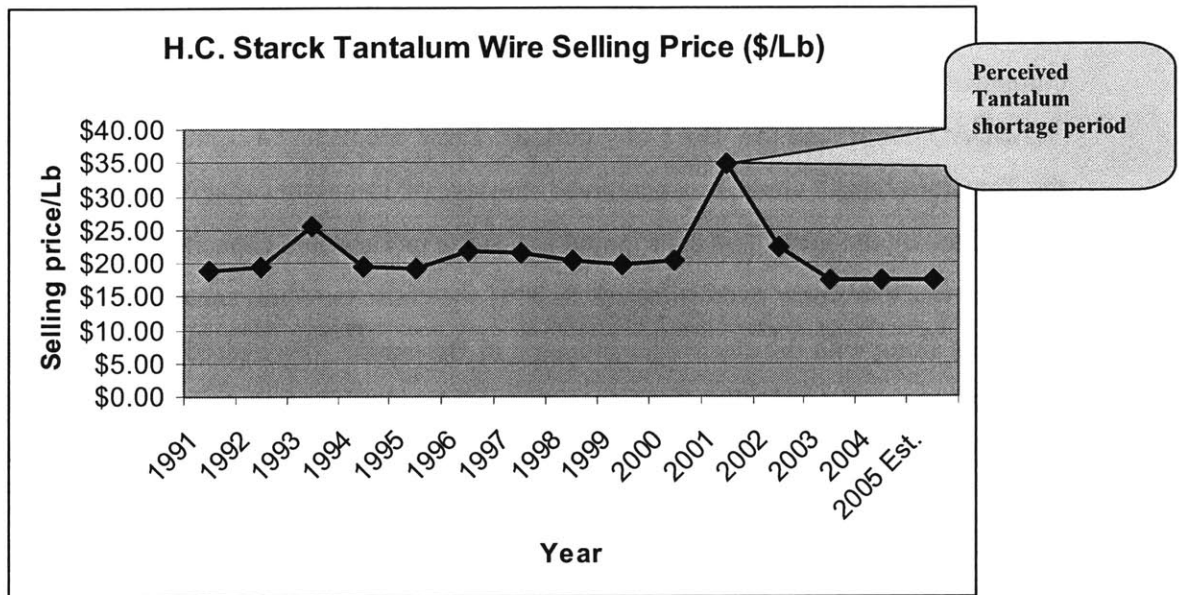


Chart 5: H.C. Starck’s Tantalum Wire selling price (\$/Lb) trends

Capacitor Manufacturers:

As shown in chart 4, most Tantalum wire is sold to capacitor manufacturing companies, therefore these manufacturers have a very strong influence on the Tantalum wire market health. However, capacitor manufacturers do not independently determine the volume of capacitor production – they rely on the electronic industry. The electronic industry is very important to the tantalum business, as more than 70% of tantalum material is used in electronic end markets, and electronics thus greatly influence the entire Tantalum supply chain. In fact, past data shows that when the electronics industry grows by 10%, the entire tantalum supply chain must grow by 8%⁶. Few other supply chains are so greatly affected by a single segment of their business⁷. Chart 6 shows another key link between the electronics industry to the tantalum business industry, as demonstrated by the correlation between the electronics equipment market (in \$K) to the amount of Tantalum capacitors needed; The chart indicates that Tantalum capacitors became a greater part of the electronic industry over time (roughly 20% increase in the ratio of Tantalum capacitors per Electronic equipment shipments between 1992 to 2002).

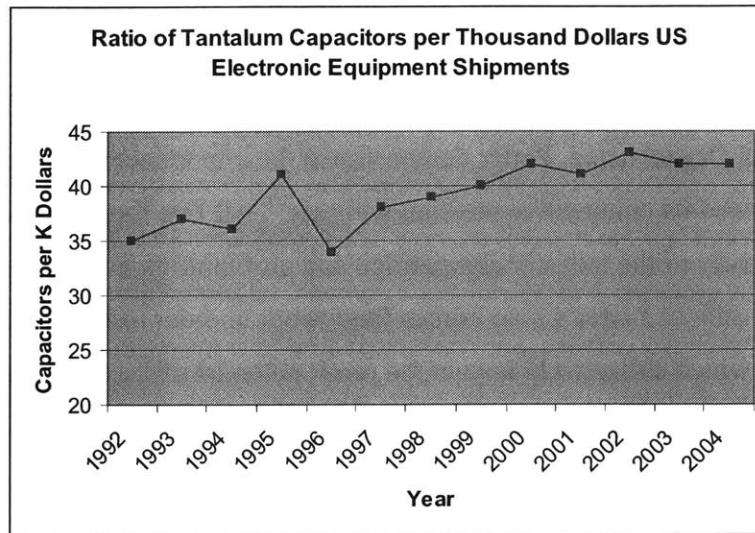


Chart 6: Ratio of Tantalum Capacitors to Electronic Equipment shipment

Original Equipment Manufacturers (OEMs): The capacitor makers sell their tantalum capacitors to companies that manufacture end products such as cell phone producers (i.e. Motorola, Nokia), PC/Laptop producers (i.e. Intel, AMD), automakers (i.e. Ford, GM), military applications, etc. Some of these companies manufacture their products in-house, while others outsource to Contract Service Manufacturers (CSMs). Since these OEMs directly interact with the end consumers (i.e. retailers & the mass public), they possess the most accurate market intelligence in terms of trends, long range forecasts, as well as strategic plans for new products. One of the challenges for other partners in the supply chain, such as HC Starck, is communicating with these OEMs to better utilize this knowledge for product development as well as production planning.

2.5 Tantalum Wire Market Attractiveness Analysis

2.5.1 Academic Literature Benchmark: Porter’s Five Forces Framework

The essence of formulating a strategy is relating a company to its environment. Therefore analyzing the external environment is a crucial phase in any strategic planning process⁸.

Many frameworks, tools and techniques have been developed to assess and evaluate the external environment; however Michael Porter’s Competitive Forces Model (commonly referred to as Porter’s Five Forces Model) is by far the most widely used framework for an assessment of the profit potential in the industry, also called ‘market attractiveness’⁹. Drawing on rich body of theoretical and empirical research in the subfield of economics known as Industrial Organization, Porter demonstrated the importance of understanding the firm’s industry and its competitive position within it¹⁰. All five forces jointly determine the intensity of the industry competition and profitability, as shown in chart 7 below. This thesis utilizes Porter’s Five Forces framework in order to highlight the structural features which collectively impact the profit potential of the Tantalum Wire market.

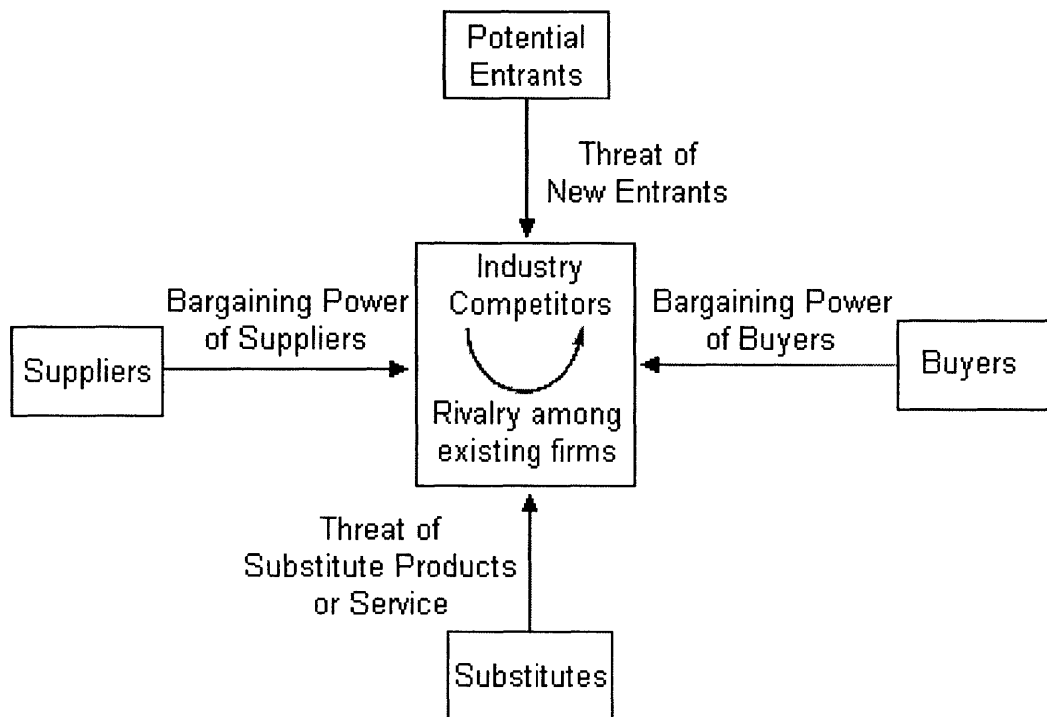


Chart 7: Porter’s Five Forces framework for market attractiveness assessment

2.5.2. Implementing Porter’s Framework in the Tantalum Wire Market

The following section reviews each of Porter's five forces with regards to the Tantalum Wire industry. Each force is first described generically for its intent and potential sources, and then a specific analysis of the force is detailed in the context of the Tantalum Wire industry, followed by a description of the sources of strengths and weaknesses in each force. A qualitative score of Low/Medium/High was assigned for each of the forces to signify its strength level in the Tantalum Wire industry.

The first force, **Barriers To Entry**, considers the likelihood that new firms will enter the industry. Each industry possesses characteristics that protect the high profit levels of firms in the market and inhibit additional rivals from entering the market. The barriers to entry in the Tantalum Wire industry were concluded to be of medium strength, while considering major components as capital requirements, intellectual property issues and break even volume requirements. The initial capital investment needed to open a wire factory based on current industry standards averages around \$50 to 60 million dollars. This is not a negligible amount, but is not considered significant for large corporations or companies looking to expand their businesses. Any entrant to the Tantalum wire business will need to gain sufficient technical knowledge in the engineering and manufacturing processes, quality control, efficiency and more. However, since the Tantalum wire manufacturing technology did not change much over the past decades, most patents have either expired or have been licensed, to an extent where the wire technology is not considered to be a very challenging one to obtain these days. Last, in order to achieve positive profits in the Tantalum wire business, a manufacturing facility must run in a minimum volume that will enable break-even profitability. This volume is measured in wire pounds per year, and currently stands on an average of 100,000 Lbs/year as a minimum point. This in fact is a barrier to entry since an entrant will need to obtain sales in at least that volume before being profitable. These aspects combined were considered to be of medium strength as a barrier to entry to the Tantalum Wire industry.

The second force, **Buyer Power**, considers the impact that customers have on a producing industry. The major components that imply an existence of buyer power in an industry are the buyer concentration level, the proportion of the output being purchased by industry buyers, the level of product standardization (i.e. is close to or is a

commodity), as well as any buyer switching costs.¹¹ The power of buyers in the Tantalum Wire industry was concluded to be of high strength when considering the major components above. First, Tantalum Wire products have become a commodity several years ago when all producers started to manufacture the same quality and similarly specified wires. To date there is no real differentiation between Ta wire made by different producers in the industry, i.e. there is no sustainable advantage to companies like H.C. Starck in their wire products. Second, in today's Ta wire market there is essentially no switching costs associated with Ta wire manufacturers- a buyer (for example, a capacitor producer like Vishay or Kemet) can easily switch between wire suppliers with no impact to its business since the product is almost identical in all aspects. Third, more than 90% of the Ta wire volume is sold to Ta capacitors manufacturers¹². This brings a lot of power to the hands of the buyers as they have a significant influence over the wire industry revenues and profits. Last, as described in the supply chain section above, the main possession of brand power in this industry is positioned at the OEMs level...i.e the household brand names like Nokia, Motorola, Intel, Ford, etc. These OEMs (who are the 2nd-teir buyers for the Ta wire makers) have a recognizable brand name and utilize it to increase their market power, as apposed to wire makers like HC Starck who do not have significant brand equity. These aspects combined indicate a high level of power possessed by the Tantalum Wire industry buyers.

The third force, **Supplier Power**, considers the buyer-supplier relationship between the industry and the firms that provide it with the raw materials used to create products. Suppliers, if powerful, can exert an influence on the producing industry, such as selling raw materials at a high price to capture some of the industry's profits¹³. The major components influencing supplier power in an industry are the supplier concentration level, alternative sources of raw materials, the existence of long term contracts with industry suppliers, and a credible forward integration threat. The power of suppliers in the Tantalum Wire industry was concluded to be of medium strength when considering the components above. First, the level of supplier concentration in the Tantalum Wire industry is high, since the raw materials suppliers are the Ta mining companies – and there are only a few of them controlling most of the market. This means that these mining companies exert some power due to their low number and high market share. Second, there is no real alternative to Tantalum extracts from mines; currently, most of the Ta raw

material is produced from the Ta minerals via mining companies. Only a fraction of the raw material is sourced via recycled Ta (less than 20%). Since there is no alternative source on earth for raw Ta aside from the Ta mines, buyers of Ta like H.C. Starck and others can not threaten to pursue other paths to get raw Ta and hence the supplier power is increased. If the electronics market demand will grow and will require more Tantalum capacitors, the raw material prices will rise and the profits will be captured most likely by the mining companies. Third, in the past few years, long term contracts have become standard procedure in the Ta market, where mining companies and Ta processors sign contracts to ensure long term raw materials supply in standard pricing. Terminating such contract by either side will result in penalties. Last, there are no significant forward integration threats in the industry; however some capacitor makers now own small portions of Ta mining companies to ensure the incentives are aligned. These aspects combined indicate a medium level of power possessed by the Tantalum Wire industry suppliers.

The forth force, **Threats of Substitute Products**, considers the affect on a product demand due to the existence and cost of a substitute product. Substitute products affect a product's price elasticity - as more substitutes become available, the demand becomes more elastic since customers have more alternatives. A close substitute product constrains the ability of firms in an industry to raise prices¹⁴. The threat of substitutes in the Tantalum Wire industry was concluded to be of high level due to the existence of affordable capacitor alternatives and improvement in these alternative capacitors' performance in recent years. Any substitute for the Tantalum capacitors will directly impact demand for Tantalum wire products. In the past, Ta capacitors were considered far superior to all other capacitors in all performance, quality & reliability indicators¹⁵. However, with recent advances in technology, other types of capacitors are now considered fair alternatives to Ta capacitors: the main competition comes from Ceramic and Aluminum capacitors. Both Ceramic (also known as 'MLC': Multi Layer Ceramic) and Al capacitors have bridged some of the performance gaps & are now competing head to head in some fronts versus the Tantalum capacitors. Ta capacitors are still unbeatable at longevity, volumetric efficiency (i.e. space) and reliability¹⁶. Chart 8 below describes the Ta capacitors struggle with its competitor products, indicating that the Ta capacitor market is facing a tough competition from several alternative products in parallel, all

trying to gain market share from Ta capacitors. This of course reduces the overall Ta capacitors share of the pie¹⁷.

Chart 8: Global Consumption Value for High Capacitance Capacitors

In addition to the performance overlap with other capacitors, the competing capacitors all use cheaper raw materials than the Ta capacitors – this is due to the fact that Ta is a rare metal and thus more expensive, while other capacitors use cheaper raw materials such as Aluminum, Nickel, Copper, and Niobium. Chart 9 describes the cost difference in raw materials between the different capacitors, which leads to a significant difference in the market prices for these alternatives – as of 2005 the price of a Tantalum capacitor was almost three times the price of an Aluminum capacitor.

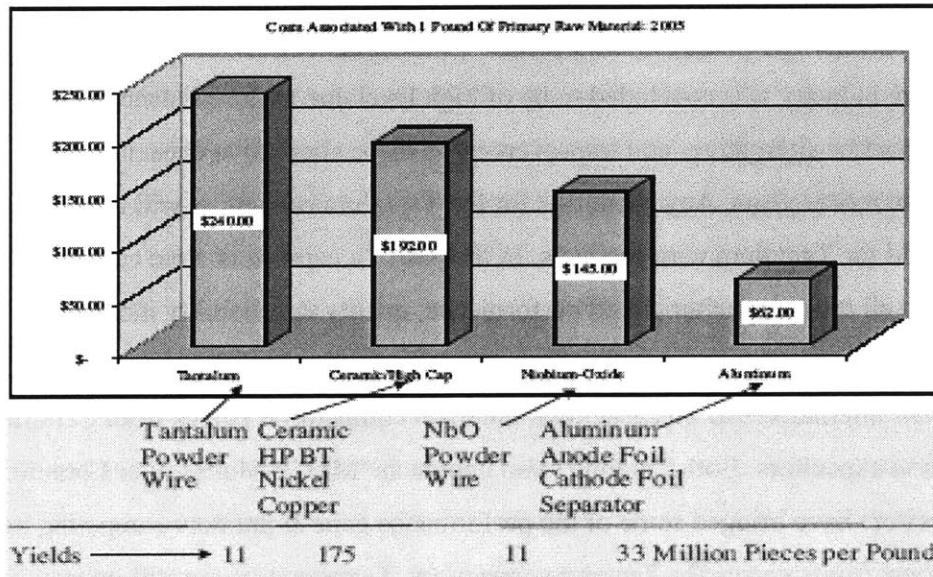


Chart 9: Comparison of raw materials cost in different capacitor types

These aspects combined indicate a high level of threat posed by substitute products in the Tantalum capacitor market, which directly influences the Tantalum wire market as well.

The Fifth and last force, **rivalry among existing firms**, considers how incumbent firms strive for a competitive advantage over their rivals. Economists measure rivalry by indicators of industry concentration - when a rival acts in a way that elicits a counter-response by other firms, rivalry intensifies. The intensity of rivalry commonly is referred to as being cutthroat, intense, moderate, or weak, based on the firms' aggressiveness in attempting to gain an advantage¹⁸. The level of rivalry within the Tantalum Wire industry was concluded to be high, based on two major components reviewed below: the existence of a price war, and the under utilization of current manufacturing firms. In the past several years the Ta wire products have become a commodity, and as such are undifferentiated in the customers' eyes. The only way for incumbents to compete in this industry is over price. The entrance of the lower cost Chinese competitors into the Ta wire industry resulted in a price war between existing firms, a war which ultimately decreased profit margins for all companies due to increased rivalry¹⁹. In addition to the price war situation, the Tantalum Wire industry is regularly under-utilizing its manufacturing capacity²⁰. Due to historical upturns (and perceived upturns) in the late 90's, many Ta wire manufacturers added capacity to their existing factories as well as opened new factories. Since the market since downsized significantly, the supply chain was left with a lot of excess capacity and un-utilized equipment on floor. The current average utilization for Ta wire across all firms stands on 68% which is relatively low²¹. Since adding this wire manufacturing capacity required a significant fixed cost investment in equipment and floor space, the competition intensifies between rivals in the Ta wire market to gain volumes and market shares in order to compensate for their investments with additional volume. These aspects combined indicate a high level of rivalry within the Tantalum wire industry firms.

Porter's Competitive Forces Model is a well defined part of strategic analysis and market attractiveness. By combining the separate analysis above of the five forces in the context of the Tantalum Wire industry, it indicates a low market attractiveness level as a whole. Based on Porter's framework, the low level of attractiveness is true for incumbent firms currently in this market.

In the next section I will evaluate what actions H.C. Starck can take to improve their position in this challenging market based on Porter’s academic literature frameworks and the company capabilities.

2.6 H.C. Starck Strategic Responses

2.6.1 Literature Benchmark: Michael Porter’s Framework

If one of the primary determinants of a firm's profitability is the attractiveness of the industry in which it operates, an important secondary determinant is its position within that industry. Even though an industry may have below average profitability, a firm that is optimally positioned can generate superior returns²².

A firm positions itself by leveraging its strengths. These strengths ultimately fall into one of two headings: Cost Advantage or Differentiation²³. By applying these strengths in either a broad or narrow scope, three generic strategies result: cost leadership strategy, differentiation strategy, and focus strategy. These strategies are applied at the business unit level. They are called generic strategies because they are not firm or industry dependent.

The following table illustrates these three generic strategies based on Porter’s framework:

<i>Target Scope</i>	<i>Competitive Advantage</i>	
	Low Cost	Product Uniqueness
Broad (Industry Wide)	Cost Leadership Strategy	Differentiation Strategy
Narrow (Market Segment)	Focus Strategy (low cost)	Focus Strategy (differentiation)

Chart 10: Porter’s generic strategies table²⁴

These three generic strategies will be briefly reviewed below with a description of the basic requirements that a firm must possess in order to pursue each strategy. Then, an analysis of

H.C. Starck's best strategy will be described along with the reasons why that specific strategy was chosen.

The first generic strategy, a **Cost leadership strategy**, calls for being the low cost producer in an industry for a given level of quality. The firm sells its products either at average industry prices to earn a profit higher than that of rivals, or below the average industry prices to gain market share. In the event of a price war, the firm can maintain some profitability while the competition suffers losses²⁵. Some of the ways that firms acquire cost advantages are by improving process efficiencies, gaining unique access to a large source of lower cost materials, making optimal outsourcing and vertical integration decisions, or avoiding some costs altogether. Firms that succeed in cost leadership often have specific internal strengths such as access to the capital required to make a significant investment in production assets (this investment represents a barrier to entry that other firms may not overcome), skills in designing products for efficient manufacturing, high level of expertise in manufacturing process engineering, efficient distribution channels (i.e. cheaper than competition), and an ability to purchase raw materials at lower cost. The low-cost strategy also carries some risks; for example, other firms may be able to lower their costs as well. As technology improves, the competition may be able to leapfrog the production capabilities, thus eliminating the competitive advantage.

The second generic strategy, a **Differentiation strategy**, calls for the development of a product or service that offers unique attributes that are valued by customers and that customers perceive to be better than or different from the products of the competition²⁶. The value added by the uniqueness of the product may allow the firm to charge a premium price for it. The firm should strive for the higher price to more than cover the extra costs incurred in offering the unique product. Because of the product's unique attributes, if suppliers increase their prices the firm may be able to pass along the costs to its customers who cannot find satisfactory substitute products easily. Firms that succeed in a differentiation strategy often have specific internal strengths such as access to leading scientific research, highly skilled and creative product development team, strong sales team with the ability to successfully communicate the perceived strengths of the product, and a corporate reputation for quality and innovation. They may also possess a stronger knowledge of the market. The risks associated with a differentiation strategy include

possible imitation by competitors due to challenging IP issues and changes in customer tastes.

The third generic strategy, a **Focus strategy**, concentrates on a narrow segment and within that segment attempts to achieve either a cost advantage or differentiation. The premise is that the needs of the segment can be better serviced by focusing entirely on it²⁷. Firms that succeed in a focus strategy are usually able to tailor a broad range of product development strengths to a relatively narrow market segment that they know very well. Some risks of focus strategies include imitation by a competitor and changes in the target segments.

The following section will review the recommended generic strategy for H.C. Starck in the Tantalum Wire business.

2.6.2 Analysis of H.C. Starck Options In Light Of Porter's Generic Strategies:

In the case of H.C. Starck in the Tantalum Wire industry, the business unit is targeting a broad scope (i.e. industry wide domination in Tantalum Wire) and not a narrow market segment. Therefore, Starck's competitive advantage can only be either 'low-cost' or 'product uniqueness' (also known as 'perceived quality'). Any other form of differentiation will ultimately fall in one of these two categories. The following section will examine both options and identify what strategy Starck needs to execute in order to survive in this industry.

H.C. Starck **cannot achieve industry-wide cost leadership** as a sustainable competitive advantage, for several reasons: First, Starck's core cost structure is not lower than that of the competition – especially the Chinese companies that have entered the market in the past several years. These companies have an inherited lower labor rate than in the US as well as some more flexibility in purchasing Ta raw materials from The Congo due to less social restrictions, and therefore have a lower cost structure to begin with, one that will be almost impossible for Starck to compete with (current estimates of this cost advantage are more than 15%). Second, H.C Starck Tantalum Wire business is currently struggling and does not have access to any significant capital investment in production assets (as opposed to R&D investments). Starck management does not want to invest its capital in the Newton site manufacturing assets. Third, many of Starck's customers are overseas

(i.e. Asia) and require a more expensive shipping process, in which case Starck does not have an advantage over competitors.

H.C Starck's competitive advantage must therefore come from the 'product uniqueness' attribute. This is achievable for several reasons: First, since its foundation, H.C. Starck (previously NRC) was known as a leading force in the research and development areas, and also achieved significant success in these fields. In fact, H.C. Starck owns many of the patents related to Tantalum Wire that were submitted throughout the years, and was always regarded as a technology leader²⁸. Second, before Ta wire became a commodity product, customers differentiated Starck's product based on their high quality and high service levels²⁹. This is not the case today since the product is a commodity and all competitors supply similar-quality products that are undifferentiated. Third, H.C Starck has good networking connections to relevant academia researchers and maintains strong connections to ongoing research fields in the US³⁰.

In light of the above analysis of H.C. Starck's options, the best strategy for Starck to pursue is a *Differentiation Strategy* where they will focus on offering a unique product or service that will enable a price premium. In this case, a differentiation strategy in the Ta wire business means developing the 'next generation Ta wire product' that will be more technically advanced than the current Ta wire products in the market, more efficient in terms of Tantalum usage (less Ta = lower production cost), and will enable the next generation Ta capacitors market by enabling the high capacitance Ta powders market (as both are components in the Ta capacitors manufacturing process).

The following chapters will describe the actions initiated and pursued in the Ta wire department in H.C. Starck in order to execute this differentiation strategy (which was the focus of my project). These actions include first a new product development process assessment and adjustment to the Ta wire development, second, data collection from various sources to better understand the economical, operational, technical and financial aspects of the new product development. Finally, it will include a decision-support model development to analyze future product profitability in different market conditions.

CHAPTER 3: APPLICATION OF FRAMEWORK AT H.C. STARCK

3.1 Goal Of Framework

As was mentioned in chapter two of this thesis, there is a need for H.C. Starck Wire department to develop and launch a new Ta wire product into the market quickly. A standard product development process is usually structured around several phases that vary slightly between different companies. A typical product development process should include the following phases, as detailed in chart 11 below:

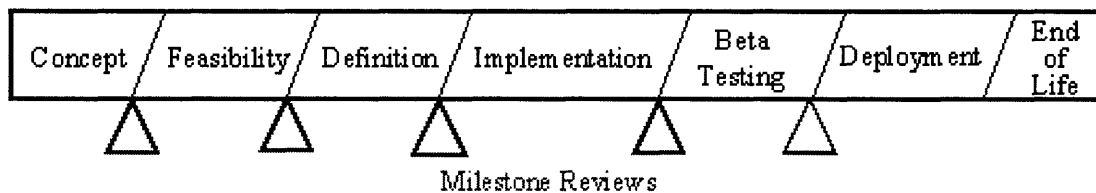


Chart 11: Typical industry product development milestones

The goal of this thesis was to support H.C. Starck in the first two phases of the product development life cycle above (the Concept and Feasibility phases).

These phases include conducting a comprehensive **feasibility analysis** that will have an economic study (costs/benefits), a market study (market size and competition), an operational study (impact to current operations) as well as a technical study (narrowing down feasible technologies). My approach was to collect all relevant data and to model it into a decision-support model that includes all aspects of the feasibility study. Such a model was developed during my internship to simulate multiple scenarios resulting from the current uncertainty in the market, and to forecast the proper response to these scenarios. This decision-support model will help H.C. Starck wire department in making viable business decisions with the new product development efforts, and will help management better comprehend the risks and uncertainties in launching such a product, as well as the possible rewards in terms of Return Of Investment (ROI) and Net Present Value (NPV) analysis.

3.2 Initial Decision Tree

The decision support model was developed to follow the decision tree faced by H.C. Starck when trying to decide their product development strategy. Each branch on this tree was later separately modeled with its unique parameters and fed into the model.

Chart 12 describes the decision tree that was the source of the decision support model.

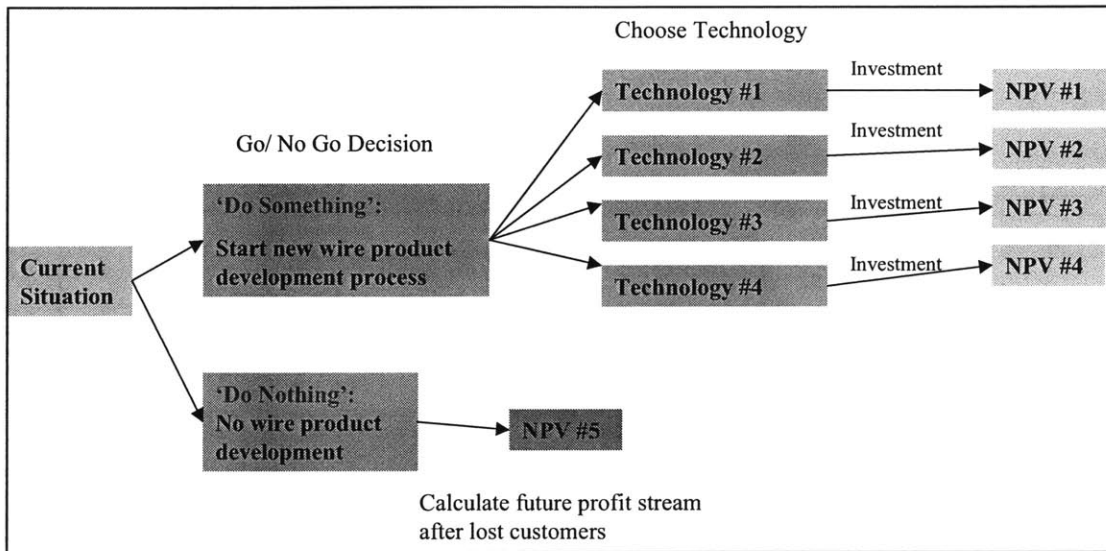


Chart 12: H.C. Starck initial decision tree

Granted, there are additional scenarios and decision branches that the company can choose to explore but are not shown in the decision tree above, since the focus of this thesis is the scenarios dealing with a strategic decision whether or not to launch a new Ta wire product into the market, with the goal of ‘product differentiation’, given the current market conditions in the industry, as described in chapter two using Porter’s five forces framework. All factors described above (in section 3.2) were modeled and were fed into a decision support model to simulate real-life behavior of the Tantalum wire market over ten years.

3.3 Modeling The Uncertain Tantalum Wire Business

Since there are so many uncertainties in the Tantalum wire business, it is difficult to model or simulate all possible scenarios. The model developed takes into account factors that account for the most critical aspects of a new product development process, based on the Tantalum Wire business structure at H.C. Starck. Chart 13 describes these key aspects and the key inputs into the product development model.

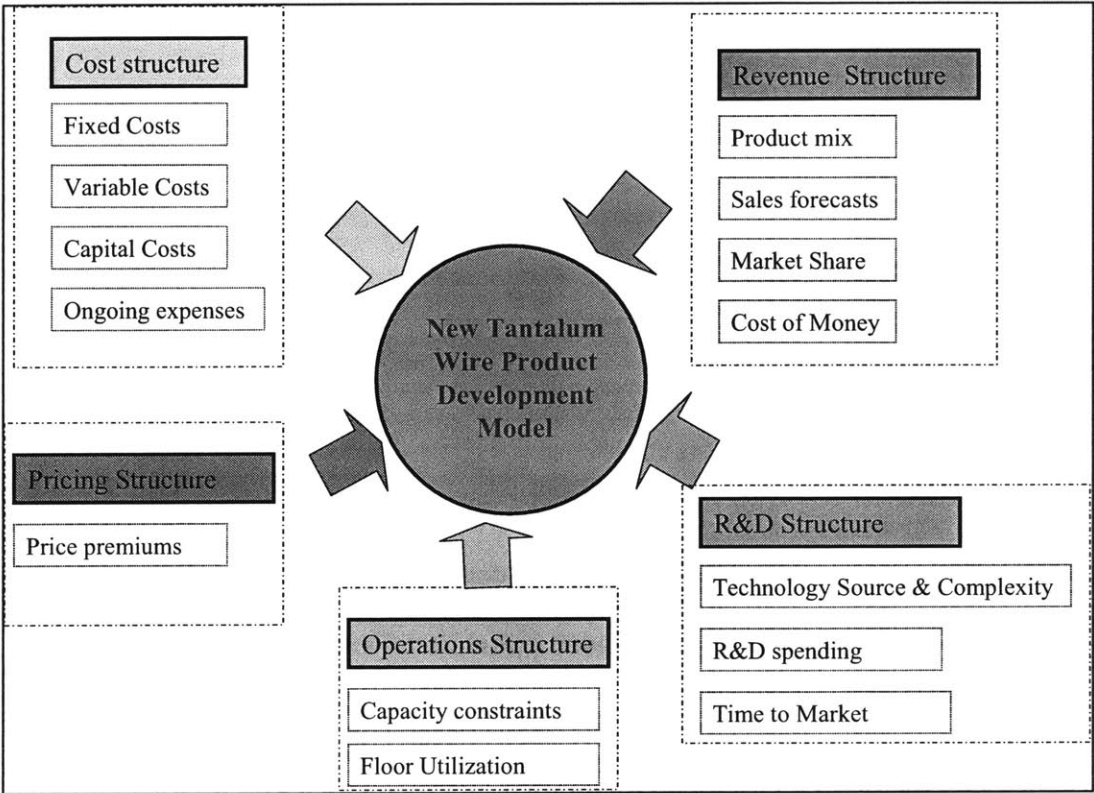


Chart 13: Tantalum Wire business structure and model inputs

3.3.1 Product Development Model inputs

In order to properly calculate each of the factors influencing the Tantalum Wire product development process, detailed information about demand, capacity, pricing and expenses is needed. Chart 14 shows a simplified list of model inputs. A more detailed overview of model inputs will be described in the upcoming sections.

Factor	Inputs
Tantalum Wire Market	<ul style="list-style-type: none"> - Market size world wide - Powder to wire consumption ratio - H.C. Starck Market share - Customer adoption rate - Future Market growth rate
Tantalum Wire Operations	<ul style="list-style-type: none"> - Manufacturing Capacity on floor - Product mix forecasts - Production utilization over time
Tantalum Wire Cost	<ul style="list-style-type: none"> - Fixed Costs - Variable manufacturing costs - Forecasted R&D costs (both capital and expenses) - Profit margins per product - Cost of money (i.e. discount rate)
Tantalum Wire Pricing	<ul style="list-style-type: none"> - Price per product (\$/lb) - Prime premium forecasts
Tantalum Wire Technology	<ul style="list-style-type: none"> - Final technology sources chosen - Complexity factors per technology - Duration of R&D process per technology - Capital investment size per technology

Chart 14: Product Development model inputs

The following sections 3.3.2 to 3.3.5 will each describe in more detail the methods that were used to determine some of the key model inputs, such as market demand, pricing strategy, technology sources and costs.

3.3.2 Market Demand Forecasts For Tantalum Wire

Determining the Tantalum Wire market demand can not be done as a direct forecast, since the demand for wire originates from demand for powder, in a certain ratio. In order to forecast accurately the future sales of Tantalum wire (in Lbs/year), a series of other factors needed to be determined first, such as powder market size, the competitive market share for H.C. Starck, and available production capacity.

Chart 15 below describes the methodology that was used to determine the initial Tantalum Wire market size for high capacitance products.

Description	average case	best case	worst case	units	Comment
Projected high CV powder market size (100% market):	4	6	2	tons/month	projected 2 year forecast (for 2007)
powder market size (100% high CV market)	8,800	13,200	4,400	Lbs/month	projected 2 year forecast (for 2007)
Wire to powder usage ratio for customers	1.80%	2.00%	1.50%	ratio	this is the usage ratio for capacitors makes
Market adaption rate for the new wire - how much of the powder customers will buy this wire	90%	95%	80%	%	assuming X% of the powder market will buy the new wire
Resulting wire consumption forecast by the customers (= net wire sales)	0.06	0.11	0.02	tons/month	2007 and earlier numbers
Resulting wire consumption forecast by the customers (= net wire sales)	143	251	53	Lbs/month	2007 and earlier numbers
Ramp up rate of future powder mkt size beyond the next 2 years:	2	3	1	tons/month	These numbers represent additional wire tons/month from the 3rd year and on
Resulting wire consumption forecast from the 3rd year and on	0.0972	0.171	0.036	tons/month	
Resulting wire consumption forecast from the 3rd year and on	214	376	79	Lbs/month	

Chart 15: High capacitance Ta wire market assessment

The Tantalum wire competitive market was modeled including H.C. Starck and all other current competitors, as shown in chart 16 below. This table is linked within the model to simulate multiple 'what-if' scenarios with different Starck market share percentages and their impact on future revenue streams and NPV.

Capacity & market share			
Supplier	Tons	K- Lbs	Market Share
A	40	88	12%
B	20	44	5%
HCST	80	175	30%
D	40	88	20%
E	40	88	15%
F	20	44	6%
G	90	198	12%
Total	330	726	100%

Chart 16: Ta Wire market competitive structure

As a result of the inputs above, the 'new wire' sales forecasts were derived for the new product, as shown in chart 17 below.

New wire ANNUAL sales forecast:	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Scenario: (wire sales in Lbs/year)										
all average case	0	0	0	1,711	1,711	2,566	2,566	2,566	2,566	2,566
all best case	0	0	0	3,010	3,010	4,514	4,514	4,514	4,514	4,514
all worst case	0	0	0	634	634	950	950	950	950	950

Chart 17: Sales forecast for new Ta wire product (for H.C. Starck)

In order to derive the forecasted sales of the current wire products (i.e. “Old wire”), the publicly available marketing information was used with regards to the entire Tantalum wire worldwide demand (published once a month) and the H.C Starck market share was used, as well as the Starck Ta wire manufacturing capacity capabilities. Capacity utilization was forecasted for every year (in a ten year forecast) and was then used to determine the sales forecasts of the current Wire products. Some assumptions were made with regards to customers buying decisions to buy both ‘new’ and ‘old’ wire in parallel to better fit their wide product offerings. As a result of the inputs above, the ‘**Old wire**’ sales forecasts were derived, as shown in chart 18 below.

Old wire ANNUAL sales forecast:	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Scenario: (wire sales in Lbs/year)										
all average case	9,515	8,962	9,714	8,606	9,985	9,665	10,227	10,818	11,439	12,092
all best case	9,515	8,962	9,714	7,307	8,686	7,716	8,279	8,869	9,491	10,144
all worst case	9,515	8,962	9,714	9,683	11,062	11,280	11,843	12,433	13,055	13,708

Chart 18: Sales forecasts for current (‘old’) Ta wire products (for H.C Starck)

Ta Wire manufacturing capacity utilization was determined for all Tantalum wire products (both old and new) to ensure operational feasibility under average line management conditions. The utilization over time is described in chart 19 below.

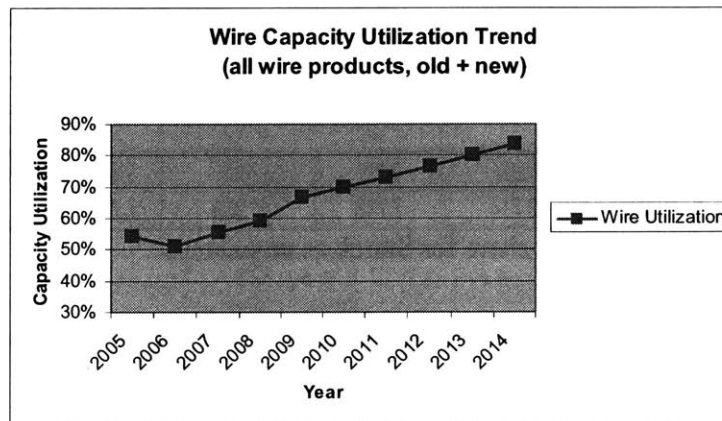


Chart 19: Ta wire manufacturing utilization trend – 10 year horizon

As seen in the initial decision tree, there is also a possible scenario called “Do Nothing”, where H.C. Starck decides not to launch a new R&D project, and therefore not to develop a new Ta wire product. This scenario means that Starck remains with the current Ta wire product offerings. This scenario also results in the fact that some of Starck’s current customers looking to buy advanced Tantalum wire products will have to look for solutions by other sources - either by the competitors (not very likely in the short term since none of the competitors are currently advanced enough in developing the new wire), or by exiting the market with some of the high-capacitance products due to lack of a compatible powder-wire combination. An assumption was also built into the model with a ‘penalty’ to Starck for not developing the new Ta product – this penalty is expressed by a portion of current customers moving from Starck to other suppliers to buy their Ta wire, and as a result, some of their Tantalum powder will be purchased together as a bundle. This penalty means that H.C. Starck will experience lost revenues in its Tantalum powder business as well as in its wire business, as these products are direct complements of each other. Since H.C. Starck considers Wire and Powder two separate ‘profit centers’ and therefore they are treated as separate accounting centers, the model takes this potential powder sales loss into account by increasing the revenue penalty (i.e. decreasing sales) account for defecting customers. In fact, by not launching a product development process and therefore not having a wire product compatible with the most advanced powder product, H.C. Starck will be penalized twice – in two separate profit centers. Since this decision support model was focused around the Ta wire department it does not reflect the actual revenues lost in the Ta powder department aside from the penalty discussed above for defecting customers. The result of the ‘Do Nothing’ scenario in terms of sales is shown in chart 20 below.

"DO NOTHING" SCENARIO										
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HCST Old Wire Sales volume (Lbs/yr)	9,515	8,962	9,714	7,746	7,988	7,732	7,670	8,113	7,435	7,860

*Volumes are based on a 30% market share for Starck as an example.

Chart 20: H.C Starck forecasted sales volume without a new Ta wire development.

3.3.3 Ta Wire Cost Structure Analysis

The current Ta wire cost structure was taken from the Wire department income statement report for the first half of 2005, and then annualized to forecasts the entire 2005 costs. The breakdown between fixed costs and variable costs can be seen in detail at appendix #1. The decision of launching an R&D effort for the new wire product development has a significant cost impact influencing several cost buckets, such as R&D expenses, capital investment, and other related expenses. First, the R&D spending increase will be needed as a first step to launch the R&D effort – starting day one. This spending includes the actual development work that will require hiring a skilled team of people dedicated to new wire development, and paying their salaries for the duration of the product development. Second, a Capital investment will be needed as well; this amount refers to the one time investment that will be required to purchase new machines, tools and utilities to start manufacturing the new product in Starck. It was assumed that this purchase would happen towards the end of the R&D efforts (i.e. in year 3 or 4 of the development process). This will of course increase the annual depreciation spending (Starck uses a 10 year straight line depreciation method). The size of the capital investment depends on the chosen technology source, as some technologies will be more complex than others to develop. Third, there will also be an impact to many ongoing expenses due to the new product development – examples are increased marketing costs, increased spending for quality assurance and engineering, etc. These costs will be higher for the first years of product development, and will go back to normal in the long term (once new product is stable in the market). The Tantalum wire cost structure is summarized in chart 21 below.

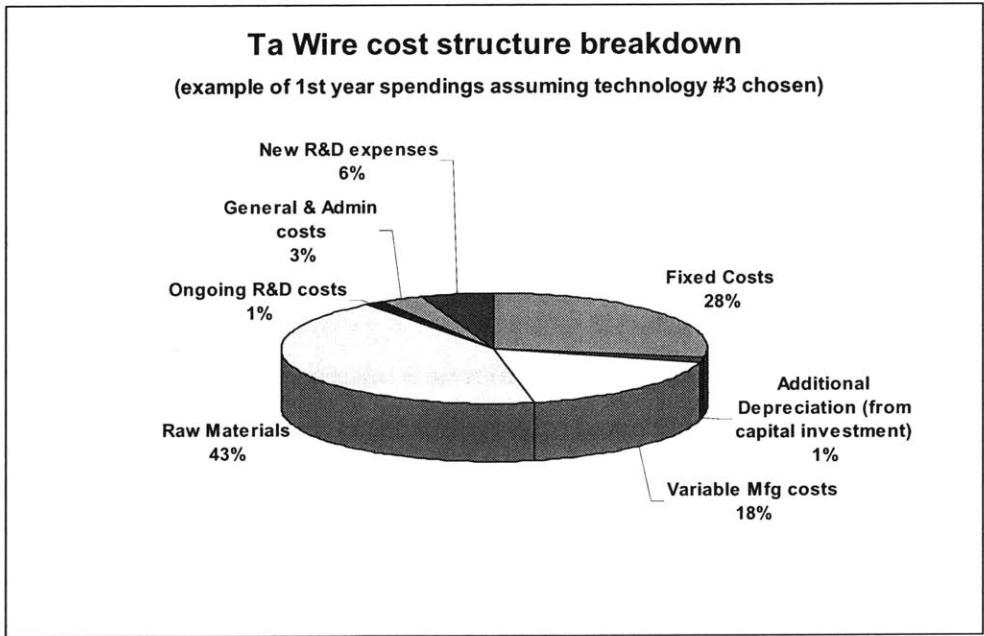


Chart 21: Ta wire cost structure breakdown

3.3.4 Ta Wire Technology Source Analysis

As mentioned above, there are several options for a technology source for the new wire production. These four technologies were derived as a result of a high-level literature search screening process to narrow down the most likely technology sources for the new Ta wire. Based on the literature search as well as the expert opinions of the HC Starck Wire technical experts, the final list of four possible technologies was derived. To date none of these technologies were proven to create the new Ta wire product and to solve current technical issues. These four potential technology sources will have to be carefully studied and evaluated during the R&D process, and one final technology source will have to be chosen for the production of the new Ta wire. Since these technology sources are not equal in terms of their complexity, proven success in other applications, market knowledge and experience with them etc, each will require a different capital investment if chosen – as indicated in chart 22 below.

Technology source	Nickname	Probability of technical success	R&D process complexity factor:	Overall complexity factor	Final complexity score	Capital investment needed
Technology 1	1	0.2	0.3	0.06	high	\$35,000
Technology 2	2	0.8	0.3	0.24	moderate	\$28,000
Technology 3	3	0.6	0.5	0.3	moderate	\$23,000
Technology 4	4	0.7	0.25	0.175	high	\$30,000

Legend
0 --> 0.2: high complexity
0.21 -->0.5: moderate complexity
0.5 -->1 : low complexity

Chart 22: Summary of the four possible technology sources with their respectable complexities.

In order to differentiate these technology sources from each other and to rank them properly, they were each assigned several factors based on current industry and academia knowledge³¹. The first factor is the probability of technical success, which considers whether a technology was ever tested before in the market, is there a solid proof of concept, how much knowledge/research exist in the open market such as academia research studies, other

companies using this technology etc. The second factor is the R&D process complexity, which considers the complexity 'in practice' of the actual development process for Ta wire, such as the probability a technology will require a longer R&D process to develop this product, a possible need for additional R&D people with a greater level of unique skills/specialties etc. Finally, each technology was assigned an 'overall complexity factor' score that was ranked from high to low and a respectable capital investment size was derived for each (this is also shown in chart 22 above).

3.3.5 Ta Wire Pricing Strategies

One of the greatest advantages for launching a new Ta wire product into the market is the ability to receive a price-premium from customers for the new product. Since Ta wire is a commodity product, any type of differentiation by the customers will be a huge advantage to HC Starck. The decision-support model considers the range of price premiums Starck can achieve by launching the new product into the market. Of course this premium will be assigned to the new product sales only, while the current wire products will not get this premium. Since there are so many different product sub-types in Ta wire (i.e. based on wire diameter, temper, customer geography etc), the model includes a product mix input that averages the entire Starck product offering with their respective current pricing. A detailed list of product offerings by Starck can be found in the appendix. The price premiums were estimated based on multiple factors, including past premiums for new products launched into the market by Starck; company marketing experts estimates based on market intelligence and demand picture for the new Ta wire product, and customers interviews with regards to a new product launch. Chart 23 below describes the potential price premium ranges for a new Tantalum Wire product.

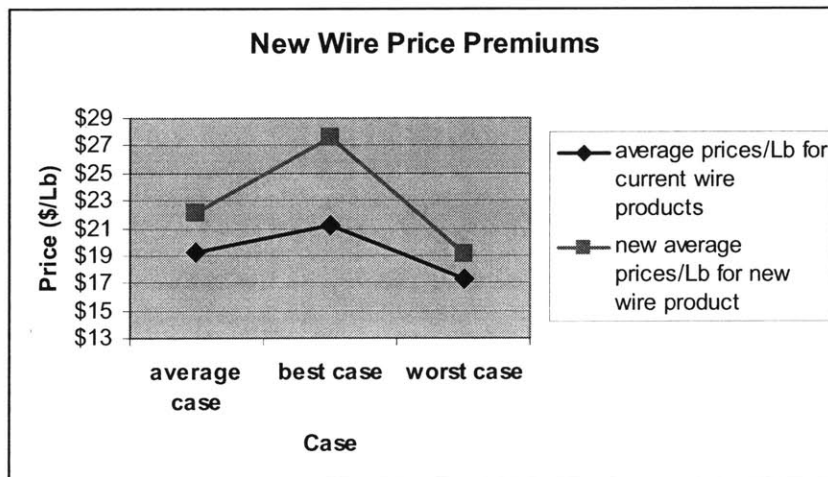


Chart 23: Ta wire pricing strategy: current & new product offering.

It is important to note that price premiums may change based on HC Starck's pricing strategy changes in the future. For example, Starck may decide to match the price of current Ta wire products to that of the Chinese competitors in order to gain market share. This will mean that the absolute price of the new product will decrease as well. Starck may decide to lower the price premium (percentage wise) for their new Ta wire products if they feel the competition threat is increasing and would like to move quickly to gain market share. The decision support model is modular and can support them in making such decisions and indicating the economical impact of such a strategic change.

Chapter 4: RESULTS AND CONCLUSIONS

The following chapter will demonstrate key results and insights enabled by the product development model discussed previously. Since the model can simulate an almost unlimited amount of scenarios with multiple variations, several key scenarios were selected as most likely to resemble the H.C. Starck business situation. This chapter will first outline the metrics used to evaluate each scenario, then it will highlight key decision points that H.C. Starck will have to investigate, and finally it will draw several conclusions and recommendations for next steps.

4.1 Economical Analysis – Selected Metrics

The decision-support model that was described in chapter three was used to run multiple scenarios with different variations in inputs. Each scenario was then analyzed for its economical and operational viability, using metrics that are aligned with the ones used by H.C. Starck accounting arm. These agreed upon metrics include Annual Profits, Net Present Value of profits, and Return On Invested Capital. The first metric, Annual Profits, is the gross profit forecasts (before tax) per year, as forecasted for the next ten years. Profits were calculated for the Ta Wire “profit center” which is a financial entity at HC Starck. The model calculates profits for the entire Ta wire department as a whole, as well as individually for the new Ta wire product only, for informational purposes. The second metrics, the NPV of Annual Profit, uses the company standard discount rate (4%) to calculate an NPV for every year based on the absolute annual profits. The third metric, ROIC (Return On Invested Capital), is determined as positive at the first year where the accumulated profits from the new wire product are greater than the initial capital investment required. This indicator provides data on how long it will take to return the initial capital investment based on the forecasted profits from the new wire only, regardless of profits from current wire products.

4.2 H.C. Starck Decision Tree – Recommended Path

As illustrated in section 3.2, H.C. Starck is facing a decision tree in which the initial step is to decide whether the Wire business will launch a new R&D process (‘Do Something’

Scenario) or remain with its current product offerings ('Do Nothing' Scenario). Using the decision support model to assist with making informed decisions, the following sections will review the results of taking different routes or branches in the decision tree, and their impact on the company.

4.2.1 Launching an R&D Project – Decision Time

A case study comparing Starck Wire department financial situation with and without a new Ta wire product in the market was analyzed using the decision support model. This case study included the base assumption of a 30% market share for H.C. Starck on average – which is the most realistic scenario based on market knowledge. A separate analysis will discuss how gaining or losing market share points impact the result of this case study. Chart 24 below demonstrates the difference in HC Starck profit stream based on the decision to launch an R&D project or not.

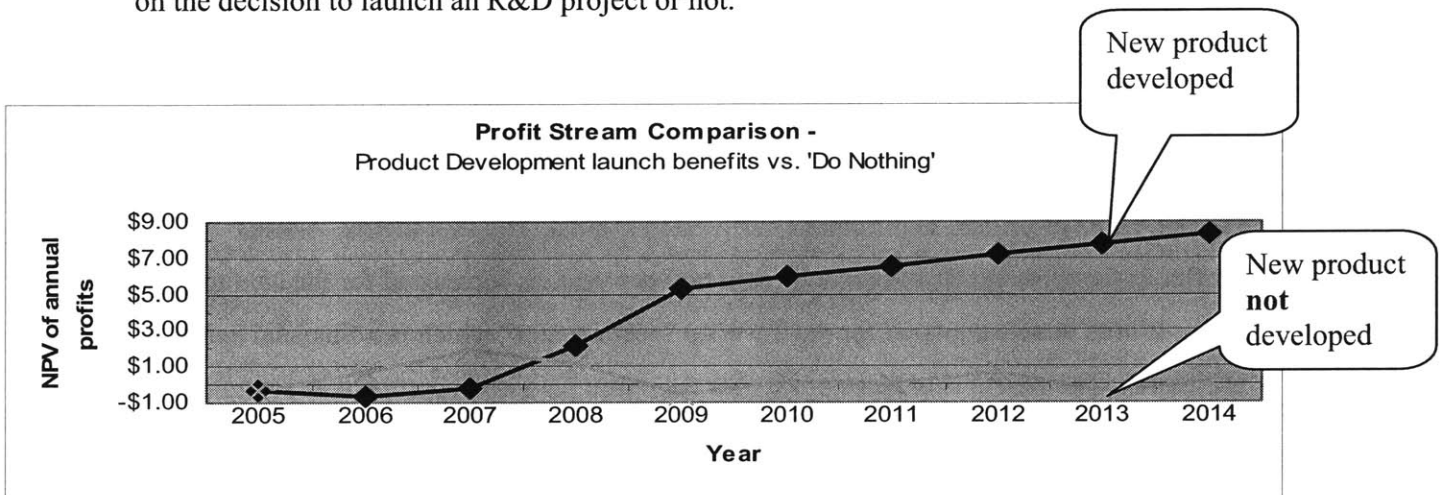


Chart 24: A comparison between 'Do Nothing' & 'Do Something' scenarios profits
(Based on a 30% HCST market share and the 'average case' demand scenario)

As seen in chart 24 above, it is clear that the 'Do Something' scenario is superior to the 'Do Nothing' scenarios (specifically for this case of 30% market share). Based on this case study, Starck should choose to launch the new R&D project and develop the new Ta wire product, with the intention of being first to market with this product. The company management should be aware of the fact that during the first 3-4 years the Newton Wire department will have to endure negative profits for several years due to the initial capital

investment and R&D spending required. This trend will be reversed in later years once the new Ta wire product is launched into the market and starts to capture revenues (exact timing of this break even point is pending the R&D process duration – most likely will start at 2008 or 2009). The ‘Do Nothing’ scenario also includes the profit penalty to HC Starck due to defecting customers in later years (for both wire and powder), once competition is able to develop the new Ta wire product and bundle both wire & powder into a more attractive package for some customers – this is another reason for the large profit stream difference. The accumulated profits discounted over a ten-year horizon for both scenarios in the case of 30% market share validates this conclusion as well, as shown in chart 25 below.

Comparing Do nothing with Do something scenarios: 30% market share				
Scenario	Total Profits new wire	Total profits all wire	NPV of total profits (all wire)	Positive ROIC at:
Do Nothing (30%)	\$0	\$3.67	\$3.32	N/A
Develop new product (30%)	\$16.60	\$55.01	\$42.16	2010

Chart 25: Summary of accumulated NPV results for profit streams
(based on average case demand and 30% HCST market share)

4.2.1.1 Launching an R&D Project versus Gaining Market Share

An interesting case study arises when reviewing alternatives to the product development case above. A similar decision was analyzed (i.e a decision to launch an R&D project) with a more optimistic assumption regarding the HCST market share: the following case assumes a 40% market share for Starck (i.e. a 10% growth from current market position). This was then compared with the ‘Do Nothing’ scenario that assumes no new product is developed. Chart 26 below demonstrates the profit stream difference as a result of the more optimistic market share assumption.

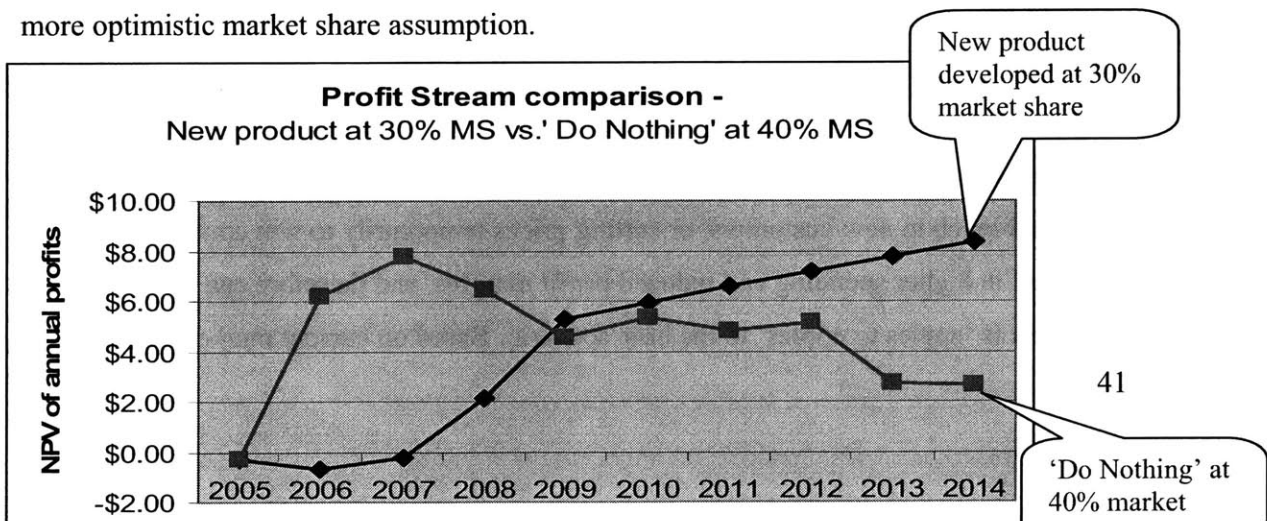


Chart 26: A comparison between launching a new product and the ‘Do Nothing’ scenario – with an optimistic HCST market share figure

Chart 27 indicates the results of the discounted profit streams from the above case study when comparing them to the base scenario on a ten year horizon.

Comparing Do nothing with Do something scenarios: 40% market share				
Scenario	Total Profits new wire	Total profits all wire	NPV of total profits (all wire)	Positive ROIC at:
Do Nothing (40%)	\$0	\$54	\$45	N/A
Develop new product (40%)	\$17	\$117	\$94	2010
Develop new product (30%)	\$16.60	\$55.01	\$42.16	2010

Chart 27: Accumulated NPV figures in comparing different market share cases

From charts 26 and 27 above it was concluded that gaining a 10% increase in market share points has a critical impact on the department profit stream – and may even change the decision to launch the R&D project. The total NPV across 10 years is in fact higher without the product development launch if the company is able to gain 10% of market share – however looking at the annual profit stream it is evident that the annual profits decrease over time (due to defecting customers penalty and no price premiums), while in the case of developing the new product but maintaining a stable 30% market share the annual profits increase over time despite the fact that the first years will have a negative annual profit due to the initial investment (both capital & expenses). It is hard to conclude what will be the better option to pursue for HCST in this case, since the accumulated NPV figures are pretty close. However, HCST should take into account additional factors on top of the total NPV – especially their confidence level in their ability to gain a 10% market share and meet the 40% figure – this is a huge challenge, especially with the tough competition from China. Such gain in market share does not usually come free, and the company will have to take several drastic actions in order to pursue a market share gain. Such actions may include increased marketing efforts world wide and branch to new customers, or cutting prices temporarily to win contracts – both will result in higher spending and reduced profit margins, and therefore can not be compared as ‘apples to apples’ to the base scenario. Based on current market situation,

one of the only ways for H.C. Starck to gain significant market share without cutting margins or increasing spending is when one of their competitors decides to exit the wire market completely and therefore the market is left with fewer incumbents, each may gain a portion of market share from remaining customers. This situation is beyond the immediate control of H.C. Stack and can not be influenced from within. Another possible way for Starck to gain market share is again beyond their control and involves a dramatic change in the cost structure of their competitors – most likely caused by a change in raw materials prices going up. In such a case, H.C Starck will be better protected due to its long term contracts with the Tantalum mining companies, as opposed to the Chinese companies relying on the volatile and risky spot market. If Tantalum prices go up (for example, due to a natural cause leading to a supply shortage), the cost advantage by Starck’s competitors will be partially reduced, and may enable Starck to gain market share points with no significant actions on their behalf. However, none of these case studies can be influenced by H.C. Starck directly and therefore are extremely risky to rely on. If HCST estimates the feasibility of getting to 40% market share as ‘high risk’ as described, then a better business decision is to launch the R&D project while committing to maintain the current 30% market share. They should also consider their confidence in the long-term market forecasts (7-10 years) versus the shorter-term market forecasts (1-5 years), the spread of the annual profits over time (increasing trend of decreasing trend) and their current financial situation (ability to invest money upfront). The recommendation in this case would be to choose the product development strategy over the ‘market share gain’ strategy, since this will give HCST a more sustainable competitive advantage in the long term, and not just a temporary advantage.

4.2.1.2 ‘Time To Market’ Duration and its Impact on the R&D Decision

Another factor in making this decision is HCST’s confidence level in the duration of the R&D project from start until product launch (i.e. ‘Time to Market’). The current best estimate stands on three years for this duration – however complexity of the technology chosen and unforeseen limitations (such as shortage in resources availability) may change this duration. Chart 28 below compares the ‘Do Nothing’ decisions with varying market shares to an R&D project that lasts one year longer than originally expected (i.e. four years of development versus three years).

Comparing Do nothing with Do something scenarios: 4 years to launch				
Scenario	Total Profits new wire	Total profits all wire	NPV of total profits (all wire)	Positive ROIC at:
Do Nothing (30% MS)	\$0	\$4	\$3	N/A
Do Nothing (40% MS)	\$0	\$54	\$45	N/A
Develop new product (4 yrs)	\$12	\$55	\$42	2012

Chart 28: Comparing scenarios assuming ‘Time To Market’ is 4 years.

As chart 28 above indicates, even with a four year ‘time to market’ duration the product development decision is still superior to the ‘Do Nothing’ case if HCST maintains its current 30% market share. However, if HCST is able to gain market share and reach the 40% point, then the difference between launching an R&D project or not is not significant financially – and in fact, the total 10-year NPV is slightly higher in the ‘Do Nothing’ case (although the spread of the profits across the 10 years is different). Again, as discussed in section 4.2.1.1 above, the confidence level of gaining a 10% market share is very high and mostly uncontrollable by H.C. Starck, and therefore should be considered as a high risk decision despite potential financial rewards.

4.2.2 Optimizing the R&D Process – Prioritization

If HCST decides to go ahead and initiate the R&D process to develop the new wire product (as recommended above), the next step for HC Starck will be to choose a technology source (out of the four technology sources identified). While this stage can only be accomplished during the R&D process via testing and elimination, and will require the actual R&D team to be hired to complete this stage, the decision-support model can be used upfront to prioritize the four technology sources based on their forecasted economic potential. This economic potential (as expressed by the profit streams and ROIC metrics) should be used by the R&D team to rank the four technologies in terms of development work and timeline. One possible prioritization method that can be implemented should be based on the technology source that would yield the best economic results long term if technically feasible. In this method, the first technology to be studied and investigated in the R&D process should be the most

profitable one. Granted there may be technical limitations and reasons why a specific technology source will be scrapped and eliminated (unacceptable product performance, for example), however the order of which to test and study these technologies is critical since it will most likely be done sequentially and not in parallel. Chart 29 below summarizes the economic potential of the four different technology sources as resulted from the decision support model. The names of these technologies were disguised due to confidentiality reasons.

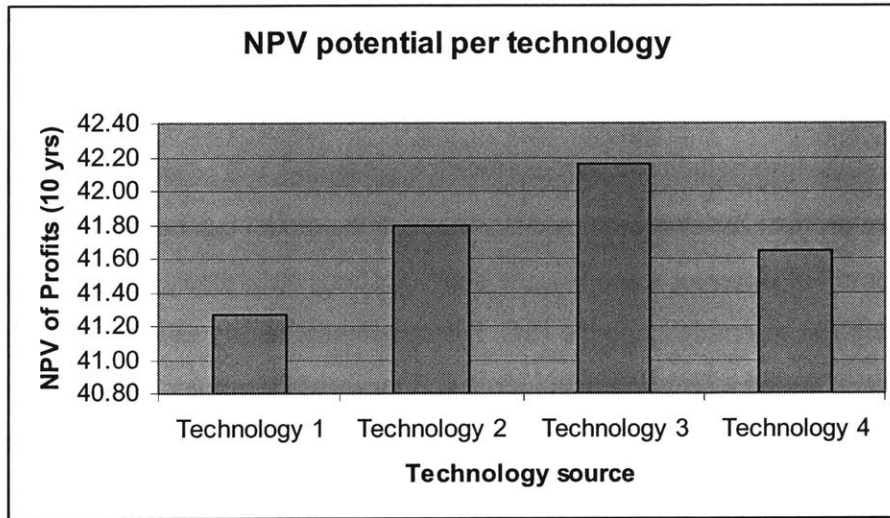


Chart 29: A comparison between economic potential of all technologies

From chart 29 above it can be concluded that the R&D process could be prioritized based on the following rank, in terms of time investment and work order:

1. **Technology #3**
2. Technology #2
3. Technology #4
4. Technology #1

This may have multiple implications on the actual R&D process, such as focusing on hiring the best R&D team with sufficient skills and expertise in technology #3 (for example, people with previous experience in this field, possibly from other applications and/or from academia), and strengthening the academic ties with universities that are currently researching this technology (initial literature search revealed such universities exist in the US). This is not the only method to optimize the R&D process based on upfront prioritization; other methods include a prioritization process that is based on time

factors and not economical potential – for example, ranking the four technologies based on the estimated duration to validate or eliminate it as a viable source. Such method is feasible, however this thesis was focused on the economical aspects and such data was not included in the model development.

In the next section I will draw several conclusions concerning the case studies reviewed above as well as generic conclusions and recommendations for H.C. Starck to pursue.

4.3 Conclusions

The above sections highlighted several interesting case studies and scenarios from the Tantalum Wire product development model. Although the model can be run to simulate an endless amount of different scenarios, the above sections described a fraction of them that bare the highest resemblance to the H.C. Starck business reality as well as several key scenarios that posed interesting managerial and business dilemmas. The conclusions drawn below are based on the financial and operational results of the model combined with knowledge of the Tantalum Wire industry, the competitive landscape and the organizational challenges faced by H.C. Starck. These recommendations were also presented to the H.C. Starck Wire department management.

It is extremely challenging for any company to operate successfully in a low-attractiveness market (based on Porter's five forces analysis results detailed in chapter two). Surviving in such a market requires an incumbent firm to gain a sustainable competitive advantage in order to be profitable³². Gaining that competitive advantage for a company producing commodity products is especially challenging when the company's manufacturing site is located in the US or in any other western countries mainly due to the basic disadvantage in cost structure originating from the higher labor rates compared to Asian countries and specifically China. Such is the case of H.C. Starck Tantalum Wire manufacturing business. Other differences in cost structure may also be present in addition to the labor rate difference, as in the case of obtaining cheaper raw materials due to less limited social restrictions in China versus the US. Based on the work and research completed in this thesis, H.C. Starck should adopt a 'Differentiation Strategy' that will differentiate their wire products from the low cost competitors. In order to pursue this

strategy, H.C Starck should launch a new R&D process with the goal of developing the next generation Tantalum Wire product – a product that will partner together with Starck’s high capacitance Ta powder to enable the next generation Ta capacitors production. Such a product is already sought after by Starck’s customers (the makers of capacitors) and will have a strong demand if launched to the market in the timely manner. In order to gain the first movers advantage with the new wire product (thus enabling a price premium), HC Starck should begin such R&D process very soon (recommended start time is the first half of 2006). A later start date will cause a later product launch date and will increase the chances of a competitor entering the market with a similar product during that time. In order for H.C. Starck to account for the volatile Ta wire market and the uncertain market and technology conditions, the wire decision support model should be used as a tool which will help management make better informed decisions by understanding which scenarios will result in a economically-viable business cases, and which scenarios should not be pursued upfront. While the model itself should only be used to assist in decision making and can highlight the best financial decisions, it should be always combined with an understanding of the real-life actions that would be needed to execute such decisions and the organizational impacts resulting from such actions, along with the firm’s confidence level in achieving these targets. H.C. Starck should also seek to create a robust link between their product development arm and their business arm. This link will enable organizational decisions to take into account both the technical and the business side of the matter at hand and will result in a better, more informed and data based decision-making process.

Appendix 1: Detailed results of selected model scenarios

- ❖ **Scenario 1:** R&D project launched, technology #3 chosen, ‘time to market’ varies (3-4 years), demand case variations (average-best-worst cases), 30% Starck market share.

1a					1b				
R&D project launched?	yes				R&D project launched?	yes			
Demand:	Average				Demand:	Best			
Product launch:	3 years				Product launch:	3 years			
Tech. Source:	Tech #3				Tech. Source:	Tech #3			
Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:	Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:
2005	-\$1.37	-\$0.31	-\$0.31		2005	-\$1.37	-\$0.31	-\$0.31	
2006	-\$2.37	-\$0.69	-\$0.66		2006	-\$2.37	\$1.04	\$1.00	
2007	-\$0.78	-\$0.24	-\$0.22		2007	-\$0.78	\$1.64	\$1.51	
2008	-\$0.23	\$2.42	\$2.15		2008	-\$0.23	\$4.41	\$3.92	
2009	\$3.56	\$6.21	\$5.31		2009	\$8.06	\$9.88	\$8.45	X
2010	\$3.56	\$7.24	\$5.95	X	2010	\$8.06	\$11.02	\$9.06	
2011	\$3.56	\$8.33	\$6.58		2011	\$8.06	\$12.21	\$9.65	
2012	\$3.56	\$9.46	\$7.19		2012	\$8.06	\$13.46	\$10.23	
2013	\$3.56	\$10.66	\$7.79		2013	\$8.06	\$14.78	\$10.80	
2014	\$3.56	\$11.92	\$8.38		2014	\$8.06	\$16.17	\$11.36	
Total:	16.60	55.01	42.16		Total:	43.62	84.30	65.67	

1c					1d				
R&D project launched?	yes				R&D project launched?	yes			
Demand:	Worst				Demand:	Average			
Product launch:	3 years				Product launch:	4 years			
Tech. Source:	Tech #3				Tech. Source:	Tech #3			
Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:	Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:
2005	-\$1.37	-\$0.31	-\$0.31		2005	-\$1.37	-\$0.31	-\$0.31	
2006	-\$2.37	-\$2.42	-\$2.32		2006	-\$2.37	-\$0.69	-\$0.66	
2007	-\$0.78	-\$2.11	-\$1.95		2007	-\$0.78	-\$0.24	-\$0.22	
2008	-\$0.23	\$0.44	\$0.39		2008	-\$0.78	\$2.42	\$2.15	
2009	\$0.98	\$3.57	\$3.05		2009	-\$0.23	\$5.72	\$4.89	
2010	\$0.98	\$4.50	\$3.70		2010	\$3.56	\$7.24	\$5.95	
2011	\$0.98	\$5.47	\$4.33		2011	\$3.56	\$8.33	\$6.58	
2012	\$0.98	\$6.50	\$4.94		2012	\$3.56	\$9.46	\$7.19	X
2013	\$0.98	\$7.58	\$5.54		2013	\$3.56	\$10.66	\$7.79	
2014	\$0.98	\$8.71	\$6.12		2014	\$3.56	\$11.92	\$8.38	
Total:	1.10	31.93	23.48		Total:	12.26	54.52	41.74	

- ❖ **Scenario 2:** R&D project launched, technology #1 chosen, ‘time to market’ varies (3-4 years), demand case variations (average-best-worst cases), 30% Starck market share.

3a					3b				
Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:	Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:
2005	-\$1.49	-\$0.31	-\$0.31		2005	-\$1.49	-\$0.31	-\$0.31	
2006	-\$2.49	-\$0.81	-\$0.78		2006	-\$2.49	\$0.92	\$0.88	
2007	-\$0.90	-\$0.36	-\$0.33		2007	-\$0.90	\$1.52	\$1.40	
2008	-\$0.35	\$2.30	\$2.05		2008	-\$0.35	\$4.29	\$3.82	
2009	\$3.44	\$6.09	\$5.21		2009	\$7.94	\$9.76	\$8.35	
2010	\$3.44	\$7.12	\$5.85		2010	\$7.94	\$10.90	\$8.96	X
2011	\$3.44	\$8.21	\$6.48	X	2011	\$7.94	\$12.09	\$9.56	
2012	\$3.44	\$9.34	\$7.10		2012	\$7.94	\$13.34	\$10.14	
2013	\$3.44	\$10.54	\$7.70		2013	\$7.94	\$14.66	\$10.71	
2014	\$3.44	\$11.80	\$8.29		2014	\$7.94	\$16.05	\$11.27	
Total:	15.40	53.93	41.27		Total:	42.42	83.22	64.78	

3c					3d				
Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:	Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:
2005	-\$1.49	-\$0.31	-\$0.31		2005	-\$1.49	-\$0.31	-\$0.31	
2006	-\$2.49	-\$2.54	-\$2.44		2006	-\$2.49	-\$0.81	-\$0.78	
2007	-\$0.90	-\$2.23	-\$2.06		2007	-\$0.90	-\$0.36	-\$0.33	
2008	-\$0.35	\$0.32	\$0.28		2008	-\$0.90	\$2.30	\$2.05	
2009	\$0.86	\$3.45	\$2.95		2009	-\$0.35	\$5.60	\$4.78	
2010	\$0.86	\$4.38	\$3.60		2010	\$3.44	\$7.12	\$5.85	
2011	\$0.86	\$5.35	\$4.23		2011	\$3.44	\$8.21	\$6.48	
2012	\$0.86	\$6.38	\$4.85		2012	\$3.44	\$9.34	\$7.10	X
2013	\$0.86	\$7.46	\$5.45		2013	\$3.44	\$10.54	\$7.70	
2014	\$0.86	\$8.59	\$6.04		2014	\$3.44	\$11.80	\$8.29	
Total:	-0.10	30.85	22.58		Total:	11.06	53.44	40.85	

❖ **Scenario 3:** R&D project launched, 'time to market' varies (3-4 years), demand case variations (average-best-worst cases) – **40% Starck market share.**

Scenario 3 (Tech #3)					Scenario 3 (Tech #1)				
R&D project launched?	yes				R&D project launched?	yes			
Demand:	Average				Demand:	Average			
Product launch:	3 years				Product launch:	3 years			
Tech. Source:	Tech #3				Tech. Source:	Tech #1			
1a	40% MS				1a	40% MS			
Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:	Year	Annual Profits new wire	Annual profits all wire	NPV of Annual profits (all wire)	Positive ROI at:
2005	-\$1.37	-\$0.31	-\$0.31		2005	-\$1.49	-\$0.31	-\$0.31	
2006	-\$2.37	\$5.07	\$4.87		2006	-\$2.49	\$4.95	\$4.76	
2007	-\$0.78	\$6.00	\$5.55		2007	-\$0.90	\$5.88	\$5.44	
2008	-\$0.23	\$9.05	\$8.05		2008	-\$0.35	\$8.93	\$7.94	
2009	\$3.56	\$13.72	\$11.73		2009	\$3.44	\$13.60	\$11.63	
2010	\$3.56	\$15.10	\$12.41	X	2010	\$3.44	\$14.98	\$12.31	
2011	\$3.56	\$16.55	\$13.08		2011	\$3.44	\$16.43	\$12.98	X
2012	\$3.56	\$17.40	\$13.22		2012	\$3.44	\$17.28	\$13.13	
2013	\$3.56	\$17.40	\$12.71		2013	\$3.44	\$17.28	\$12.63	
2014	\$3.56	\$17.40	\$12.22		2014	\$3.44	\$17.28	\$12.14	
Total:	16.60	117.38	93.54		Total:	15.40	116.30	92.65	

Appendix 2: 'Do something' scenarios summary - profit stream comparisons

(R&D project launched)

Summary of results from selected scenarios, all assuming the R&D project to develop the new Ta wire is launched and initial investment was made as needed:

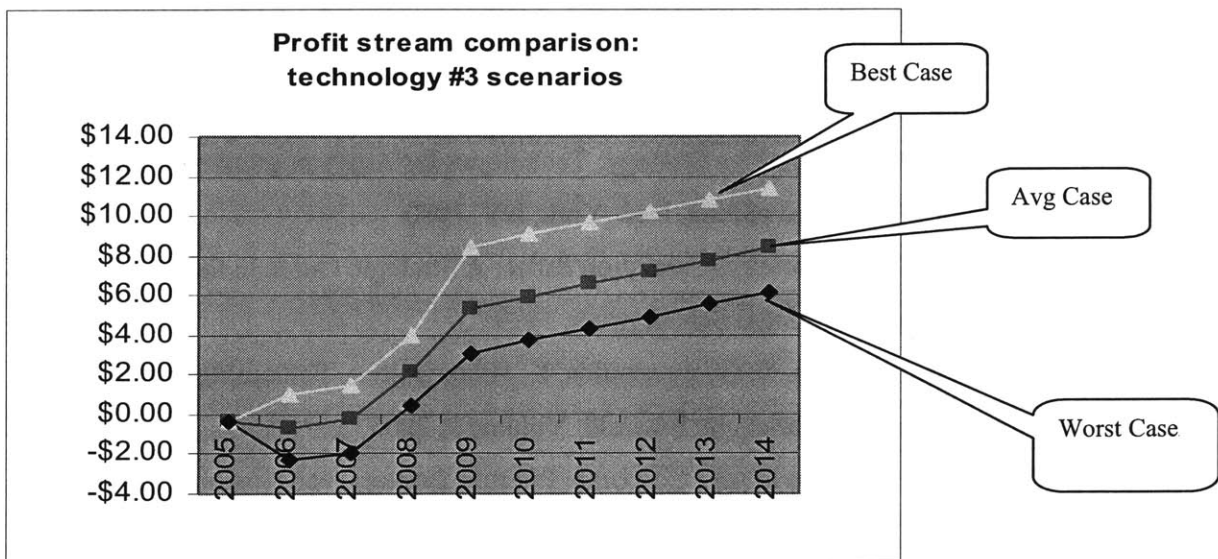


Chart 30: A comparison of profit streams based on average-worst-best case scenarios

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Endnotes:

¹ Hunziker, 2002

² Hunziker, 2002

³ Zogbi, D.M., “Tantalum Capacitors 2001-2006: Global Supply Chain and Market Analysis: 2001- 2006”, Paunamok Publications, Industrial Strength Market Research, 2005

⁴ Zogbi, D.M., “Tantalum Capacitors 2001-2006: Global Supply Chain and Market Analysis: 2001- 2006”, Paunamok Publications, Industrial Strength Market Research, 2005

⁵ Based on H.C. Starck internal presentation.

⁶ Sources: US electronic shipment data: US Dept of Commerce. Capacitor shipments are based on H.C. Starck’s estimates.

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