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Robotics in an Economic Downturn

Daniel Wilson Earley
Worcester Polytechnic Institute

Patrick-Joseph Fitzgerald Guill
Worcester Polytechnic Institute

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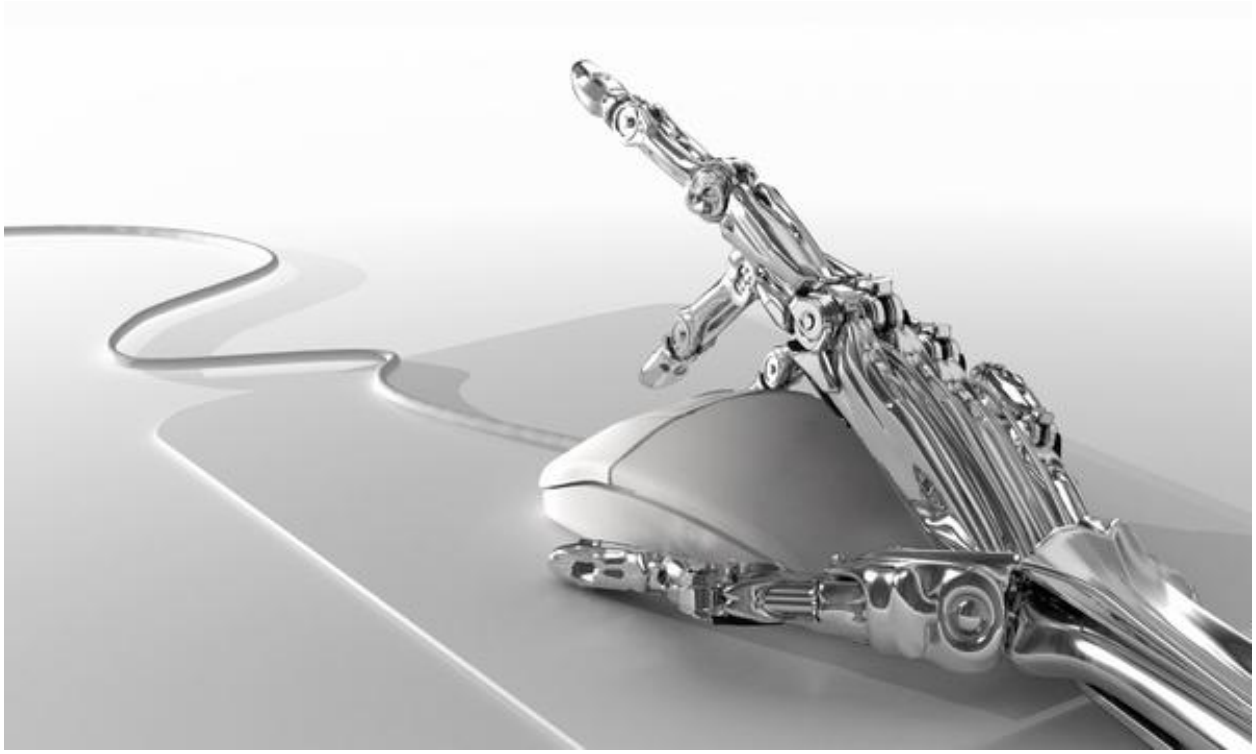

By
Daniel Wilson Earley
Patrick-Joseph Fitzgerald Guill

ROBOTICS IN AN ECONOMIC DOWNTURN

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by
Daniel Wilson Earley
Patrick-Joseph Fitzgerald Guill

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Professor Taskin Padir

Professor Taskin Padir
Worcester Polytechnic Institute

Abstract

The robotics industry, as with many other business sectors, has been greatly affected by the current economic crisis. We examine the performance of the robotics industry by tracing its operation over the past decade, through the analysis of quarterly reports by trade groups, and incorporating the knowledge and experience of industry leaders. This project: 1) assesses the current health of the robotics industry, 2) predicts its outlook for the future, and 3) reports hiring trends for robotics-related companies.

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Introduction

The robotics industry dates its origin back to the 1960s when the first robots entered into manufacturing assembly lines. Despite being nearly 50 years old, robots still possess a vast quantity of untapped potential. Yet the robotics industry, within just five short decades, has created one of the greatest impacts upon the way humankind lives in modern history. Robots have become integral components in modern human life. Robotic devices have found usage as agricultural tools and medical services to provide methods that are more efficient while maintaining the expected degree of public health and safety. Likewise, robotic technology now helps to manage many of our public transportation systems and is becoming the foundation for future military platforms. With all the uses and technological advancements associated with robotics, what kind of impact have robots had on the economy? What are the effects of the robotics industry on the job market and how are people adapting to fill these roles?

How We Got Here: The Economy

Many economists have referred to the current economic crisis as the worst financial catastrophe since the Great Depression of the 1930s. (1) Experts place different weights on the many factors that directly and indirectly contributed to the ongoing crisis. The majority agree that the causes of the recession, as well as the underlying bureaucratic and organizational interests, are complex and mutually dependent. (1)

Some of the causes, including convoluted financial securities, and international trade imbalance, helped to create a fragile financial system. Other causes, such as exorbitantly high corporate and consumer debt, increased the stress on this already fragile system. The final shocks to the system were the housing foreclosure crises and the failures of several key financial organizations. Lax

regulatory controls failed to protect the delicate economy and failed to predict the buildup of risk. (1)

While the failure may have stemmed from the collapse of the US housing bubble and its associated securities, the damage incurred by global financial institutions created ripples that affected both businesses and consumers alike. A credit meltdown reduced spending across the board and forced companies to limit investment and reduce staffing. The resulting fund restrictions prompted reorganization throughout industry including the robotics industry. This reorganization has led to the implementation of high-efficiency cost-reduction policies and more broad-spectrum products industry wide. (1)

The Robotics Industries Association

The history of robotics can be traced back to George Devol's initial work on programmable automation in the 1950s. Together with Joseph Engelberger, Devol formed the company known as Unimation and developed the world's first industrial robot, Unimate. The robot was initially sold to General Motors for transporting die-castings and welding on an assembly line (2). Since then, the applications for robotics have grown immensely. The following section provides a brief history of the Robotics Industries Association, a trade group responsible for reporting performance data for the robotics industry.

The Robotics Industries Association (RIA) was founded in 1974. Since then it has come to represent over 220 robot manufacturers, component suppliers, system integrators, end users, universities, research groups, and consulting firms (see Appendix A: List of North-American RIA Members.) One of the many functions that the RIA performs is to track the performance of the robotics

industry based on data supplied by its member companies; it has done so since 1983. These figures represent an estimated 90% of the North American robotics market. (3) The following sections will present RIA data from notable years in the past decade. This data was used to analyze trends within different sectors of the robotics industry. It was also employed to formulate a hypothesis as to what is in store for the future of the industry.

Industry Performance 1999 - 2009

1999

According to the RIA, 1999 was a groundbreaking year for the robotics industry as a whole. "Robots have made larger strides into North American Industry this year than ever before." Statistics released by the group indicated that performance during 1999 outpaced 1998 by an astonishing 62% in terms of total number of robots ordered, and 40% in terms of gross sales. The RIA reported, "Through September 1999, 13,368 robots valued at $1.11 billion have been ordered from North American manufacturers." The number of robot shipments in 1999 outnumbered those of 1998. According the RIA reports, "10,755 robots valued at $846.6 million shipped through September 1999, representing a 32% gain in units and a 13% rise in dollar value." (4)

At the time, an increase in the use of robots in industries such as plastics, consumer goods, and food processing, led to this notable surge in performance. At the same time, demand for robots in the booming automotive industry and their suppliers remained strong. According to the RIA, the leading uses for robots were, "material handling applications, followed by spot welding, arc welding, assembly, material removal, coating, dispensing, and inspection. (4)

In 1999, the RIA estimated that approximately 98,000 robots were in use in the United States. The trade group also identified a large potential for gain in the market, especially for robotic component suppliers. Analysts for the RIA stated, "less than 10% of US manufacturers who stand to benefit from the use of robots have acquired them." (4)

2001

The tragic events of September 11, 2001 and a persistent downward trend in capital purchases combined to make 2001 the worst year of sales for the robotics industry since the mid-90s. Statistics released by the RIA revealed that North American companies placed orders for only 8,964 robots valued at $680 million. This translated to a 30% decline in units ordered and a 35% decline in total dollar value from the previous year's statistics. (5)

RIA executive Donald Vincent described the one positive note for the industry during the year:

> "New orders jumped 20 percent in the fourth quarter of 2001 over the third quarter of the year, although it's much too early to say whether or not this indicates a turnaround for the robotics industry."

During the year, sales of robots for all major applications saw abrupt deterioration (See Figure 1.) Vincent noted that sales of material handling and welding robots declined less than the industry average. (5)

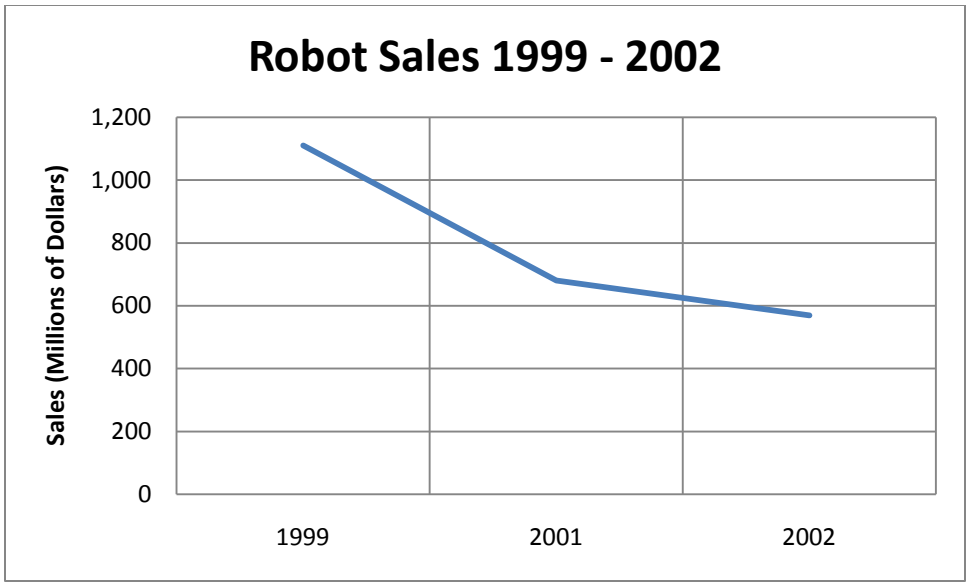


Figure 1 - Year-End Sales Figures of New Robots from 1999 - 2002.

2002

The poor sales performances in 2001 partially carried into 2002. Orders from North American robots rose 11 percent over the first three quarters of 2002 as compared to the same period of 2001. In total, North American customers, resulting in a 5% increase in units ordered, ordered 7,511 robots. Industry insiders pointed out that the highest growth of the year occurred during the third quarter. During this period, orders for new robots from North American companies increased 32% in units over the same quarter of 2001 (See Figure 2). The RIA noted that sales during the third quarter of 2002 increased 6% over the second quarter of the same year. This was notable because the third quarter is normally weaker in terms of sales. (6)

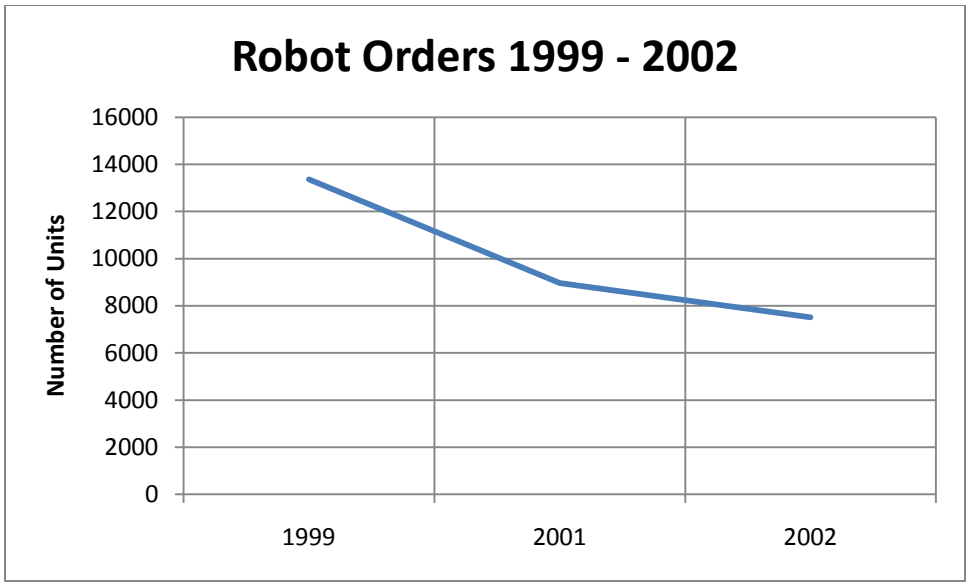


Figure 2 - Year-End Orders for New Robots from 1999 - 2002.

Donald Vincent of the RIA noted:

> "We're encouraged by the double-digit increase in North American orders through September and by the sequential increase in the third quarter. One key reason for such strong third-quarter gains could be recovery from the downturn that occurred after September 11, 2001." (6)

The largest gains in terms of applications during the year were in arc welding, dispensing and coating, spot welding and high-payload material handling and assembly robots. The only important areas that declined were found in low-payload assembly and material removal and inspection.

2004

The next notable year of growth in the robotics industry was 2004. The North American robotics manufacturers saw a 17% increase in the number of orders in the first quarter of 2004 versus the same quarter in 2003 (See Figure 3.) The RIA reported:

> "A total of 4,104 robots valued at $226.5 million were ordered by North American manufacturing companies in the opening quarter. The revenue figure is three percent higher than in the first quarter of 2003. When sales to companies outside North America are added in, the totals are 4,372 robots valued at $245.8 million, for gains of 20% in units and six percent in revenue." (7)

Amongst the applications showing the largest gains during the first quarter of 2004 were arc welding, material handling, and spot welding. Considerable growth was attributed to non-automotive industries, as well, in such areas as semiconductors and electronics, food and consumer goods, and plastics and rubber .Donald Vincent, Executive Vice President of the RIA, was very encouraged by the start of 2004:

> "The first quarter results provide further evidence that economic conditions are improving and that investment in capital equipment is on the rise again." He continued, "The robotics industry suffered when capital equipment spending dried up, and now we're benefiting from the upturn. However, the strength of the economic recovery remains uncertain, so we're not sure if the healthy gains of the first quarter will be repeated throughout the year." (7)

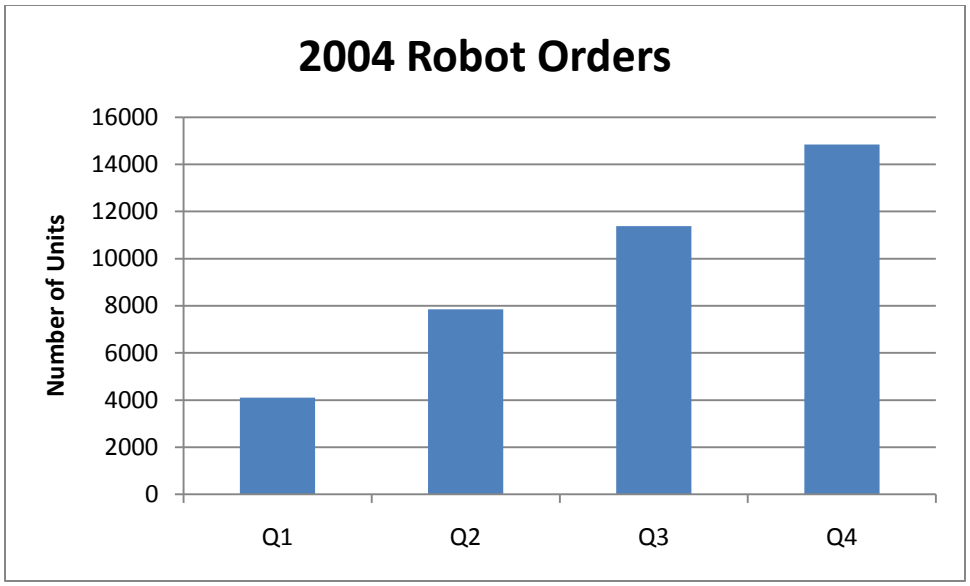


Figure 3 - Cumulative Orders for New Robots from North American Companies in 2004.

Vincent pointed out that manufacturers were struggling to reduce costs and remain competitive in 2004.

> "Some are choosing to outsource jobs to lower cost nations like China. Others are investing in robotic automation for North American manufacturing to produce higher quality products faster and more cost effectively. We believe that when more companies take a hard look at the advantages of technologies like robotics in comparison to the risks of outsourcing, they will conclude that investing in automation is the better course." (7)

To help convince companies that the implementation of a robotic workforce makes sense, the RIA held the "Robots 2004" conference. The conference focused on relevant issues such as justifying the cost of a robotic workforce and showcased companies that had successfully incorporated robots into lean manufacturing strategies to reduce overall costs. It was apparent at the conference that many companies, especially small and medium sized ones, were just beginning to look at how robots could help them meet many of their manufacturing challenges. Vincent explained, "The need to

produce higher quality products at a lower price, and to be fast and flexible enough to compete with competitors throughout the world, is leading many companies to buy robots." (7)

Vincent said that most of the gains came from non-automotive markets, a healthy sign for the industry:

> "Auto companies and their suppliers remain the largest market for robot manufacturers, accounting for about 65% of the sales in North America. However, this is down from about 75% a year ago. We're seeing very healthy gains in industries such as semiconductors and electronics, metals, plastics and rubber, food and consumer goods, and life sciences and pharmaceuticals." Orders for material handling robots, the largest application area, grew 26% in the first half of the year. Additionally, strong gains were seen in the areas of material removal and arc welding. (8)

As 2004 ended, the level of importance that robots had in the manufacturing segment was unquestionable. As a whole, North American manufacturing companies purchased 14,838 robots valued at over $1 billion during the year (See Figure 4.) This was a 20% increase over the previous year and the second best year on record. The RIA surmised that this continued growth was attributed to the fact that:

> "More and more companies recognize that robots can play a key role in keeping manufacturing jobs in North America. As the capabilities of robots have increased and the overall costs have fallen, manufacturing in North America using robots is an increasingly viable alternative to sending manufacturing jobs overseas to low-cost producers." (9)

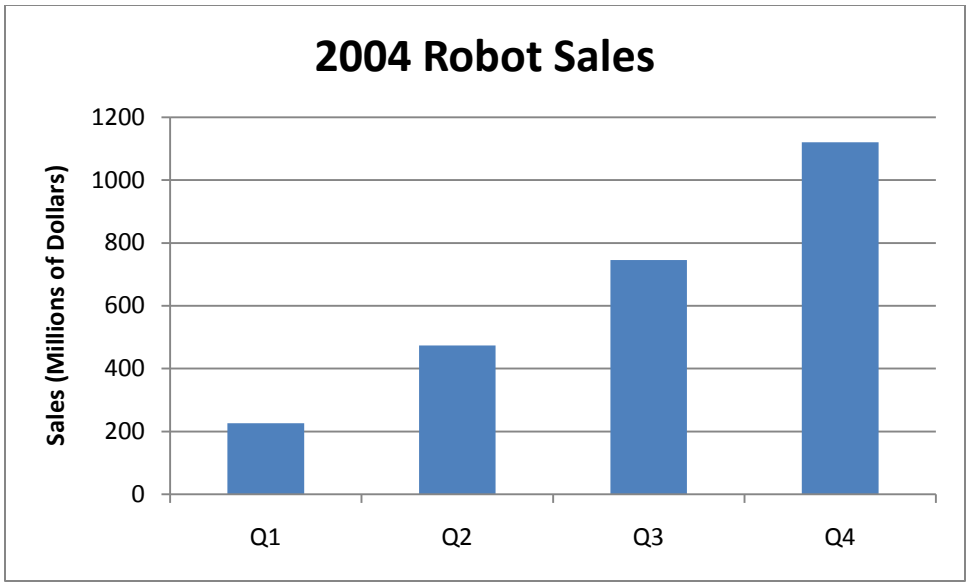


Figure 4 - Cumulative Sales of New Robots in 2004.

The trend in sales over the year showed that the robotics industry was decreasingly reliant on automotive manufacturers and suppliers. Orders from the segment accounted for 64% of the total, down from 68% in 2003. This was indicative of the fact that robots were gaining popularity in an assorted range of non-automotive industries such as pharmaceuticals, aerospace, and life sciences. Donald Vincent explained:

> "The message is spreading that robots aren't just for heavy manufacturing companies, or only for large companies. At our robotics conferences, we find a growing number of small and medium sized companies attending from industries where robots may be used in relatively small numbers today, such as consumer goods, but have enormous future opportunities for applications like packaging and palletizing." He noted that, "North American orders for packaging and palletizing robots grew 50% in 2004." (9)

Orders for robots from companies outside of North America also increased in 2004. North American robotics companies shipped 1,291 robots valued at $65 million, an increase of 152% over

orders in 2003. While impressive, the RIA was quick to caution that such tremendous gains as these should not be expected every year:

> "The last two years have been very good in large part due to the pent-up demand during 2001 and 2002 when manufacturing companies were cutting capital equipment expenditures. Once they resumed buying, robots were near the top of their shopping lists, and we have seen the results. Whether or not this continues in 2005 depends upon many economic factors. However, the long term prospects for the robotics industry remain outstanding." (9)

2005

The trend of growth accelerated in 2005 as the North American robotics industry had one of its best opening quarters on record. New robot orders were up 30% over the first quarter of 2004. In total, North American manufacturers ordered 5,316 robots, which accounted for $302.5 million in sales. Additionally, companies outside of North America ordered 272 robots valued at $18 million. Once again, material handling proved to be a strong application for robots. The segment posted a 67% gain over the results of the first quarter of 2004. Sales of arc welding and coating/dispensing robots also showed strong gains. Sales to automotive manufacturers and suppliers also continued to grow. (10)

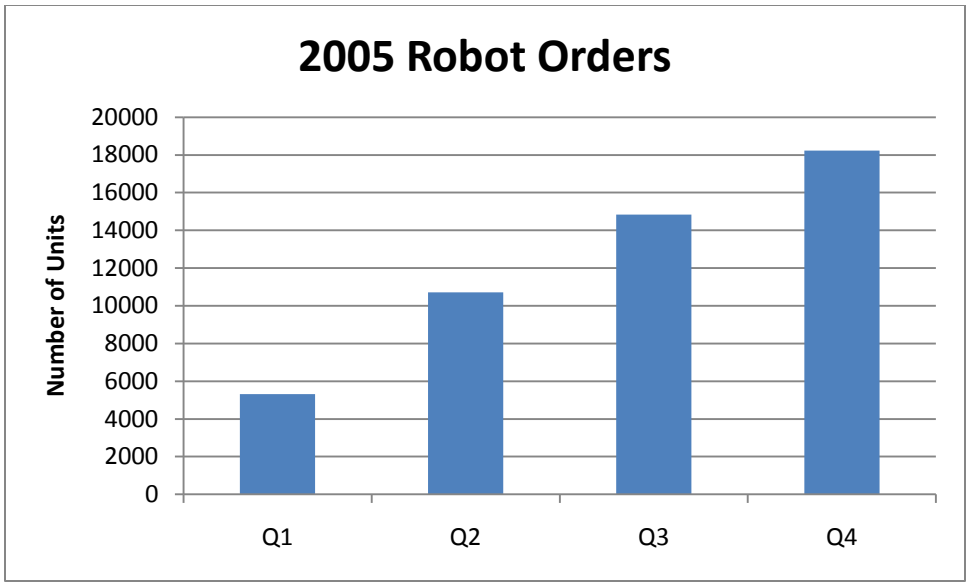


Figure 5 - Cumulative Orders for New Robots from North American Companies in 2005.

Donald Vincent stated:

> "The strong first quarter results, continuing the double-digit gains of the past two years, show that North American companies increasingly recognize the benefits robots provide in terms of quality improvement, productivity, and cost savings. If economic conditions remain healthy, we expect 2005 to be a very good year for the North American robotics industry."

He also noted that there was still a large potential market of companies that could benefit from using robots.

> "Though robots have been used in the U.S. for over 40 years, we have still only scraped the surface of potential applications. Each day, as awareness of robotics benefits spreads; new companies are taking a close look at robots to see if they make sense for their company." (10)

The second quarter of 2005 showed even more promise for the industry. Valued at $336.3 million, 5,396 robots were ordered, in North America, on pace for yet another record year (See Figure 5.)

The RIA reported, "We've been tracking the industry on a quarterly basis since 1983 and can report that there were more robots ordered in the second quarter of 2005 than in any previous quarter." Once again, demand for robots that handle material and arc weld led the surge. Orders in the automotive and metalworking industries remained especially strong.

> "Experienced users such as the automotive manufacturers are now finding expanded uses for robots as they strive to reduce costs, improve productivity, and speed time to market with their new products. New users are turning to robots to help them become globally competitive and to keep manufacturing jobs at home." Vincent noted, "From outer space to hospital rooms to living rooms, robots are playing a larger role than ever, and we expect to see this trend continue." (11)

Robotics sales set a new record in 2005, exceeding the previous high in 1999. Approximately 18,228 robots valued at $1.16 billion were ordered, during the 2005 fiscal year, an increase of 23% in units and 17% in value over the 2004 figures (See Figure 6.) Global orders and shipments also set a new benchmark in 2005. The RIA estimated that over 158,000 robots were in use in US manufacturing operations. Notable diversification of the industry included a 30% jump in the life sciences, pharmaceutical, and biomedical industries in 2005. (12)

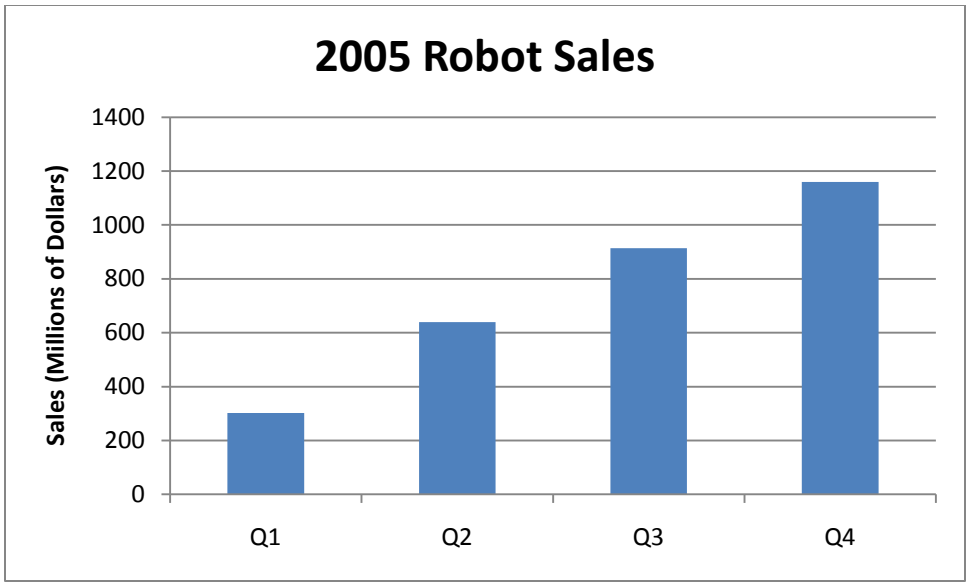


Figure 6 - Cumulative Sales of New Robots in 2005.

Not all news was as positive however. Donald Vincent explained:

> "While we expect long-term growth to continue, the near-term holds several uncertainties. Among our concerns is that in the fourth quarter of 2005, we witnessed a slowdown in year-to-year performance, as new orders in North America actually declined two percent from the same period in 2004. We're also concerned about the troubles faced by leading companies in the automotive industry, since the automotive manufacturers and their suppliers are the largest users of robots in North America." (12)

There was also growing concern about the persistent shift of manufacturing operations from North America to overseas countries. The health of the US economy was also starting to show signs of weakness. For those reasons, the RIA explained that expectations for 2006 should remain cautious. Despite the warning, Vincent predicted that long-term growth would continue to be fueled, by a growing awareness that automation has the ability to help companies contend in an ever more competitive global market:

"We've seen many examples of small, medium, and large companies in just about every industry that have taken advantage of the productivity, quality, and flexibility gains that robots provide in order to compete successfully in the global market." (12)

2006

Beginning in 2006, the robotics industry began to feel the first impacts of the economic downturn in the United States. New orders received by North American based robotics companies fell an unprecedented 38% during the first half of the year. Most of these losses were the result of what originally was thought to be a cyclic downturn in sales of robots to automotive companies. Orders in that segment declined 52% in 2006 when compared to 2005. (13)

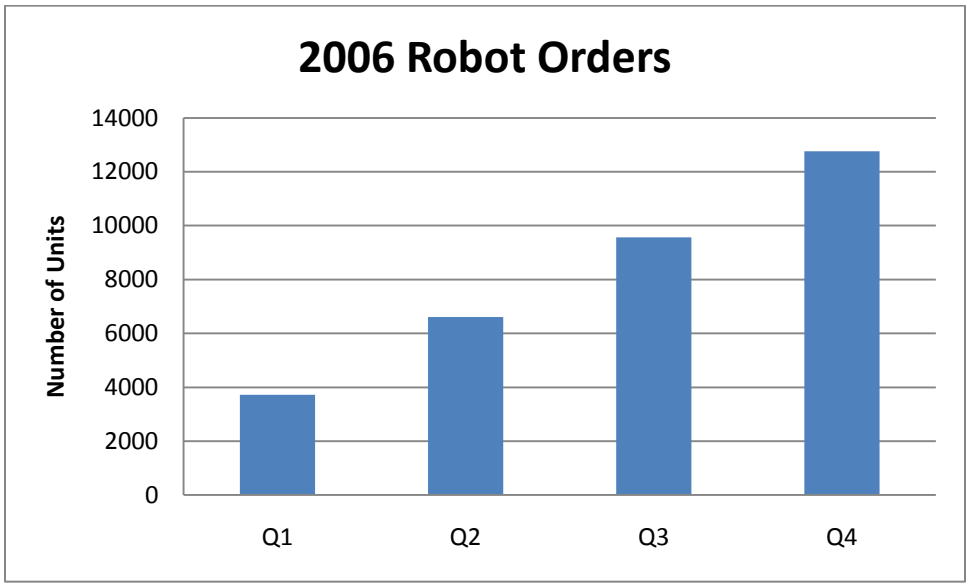


Figure 7 - Cumulative Orders for New Robots from North American Companies in 2006.

On a more positive note, increases in sales in life science, pharmaceutical, biomedical, and food and consumer goods industries carried the non-automotive segment resulting in an overall decrease in overall robot sales of 5%. Overall, non-automotive robot sales accounted for 45% of new orders

through June, a 16% increase in margin over 2005. Industry analysts were quick to realize that the long-term success of the robotics industry would depend upon expansion in non-automotive markets. The RIA speculated that the abrupt decline in sales would continue as the automotive manufacturers struggled. "Continued economic difficulties in the automotive industry are likely to slow their investments in new technologies, not just robotics." (13)

As the year progressed, the trend of low sales to automotive companies contributed to poor performance numbers for the robotics industry. Although sales to non-automotive industries recovered slightly with a decrease of only 3%, sales of automotive robots were down 49% as compared to figures from the first three quarters of 2005. This led to an overall decrease of 36% through the first nine months of the year. (14)

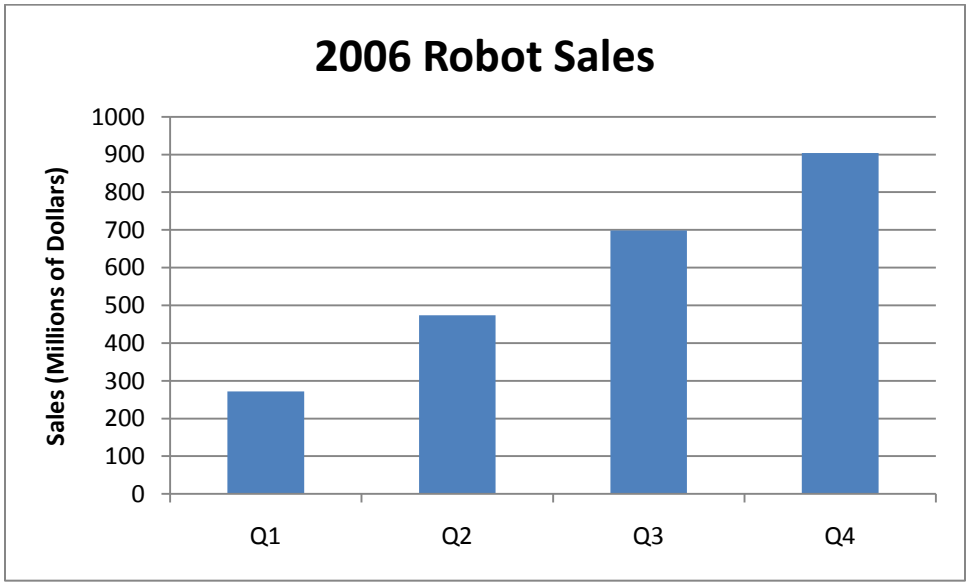


Figure 8 - Cumulative Sales of New Robots in 2009.

The end of year figures made it clear that the record number of orders for non-automotive robots were not enough to offset the steep decline in robot orders by automotive companies. As a result,

sales by North American robotics companies dropped 30% for the year. A total of 12,765 robots, valued at $904.2 million were sold to North American companies in 2006 (See Figure 7 and Figure 8.) Once again, these dramatic decreases were credited incorrectly to normal fluctuations in the business cycle of automotive companies. Donald Vincent of the RIA explained, "As expected, the automotive companies and their suppliers slowed their robotics purchases in 2006, following upon their major purchases in 2005." (15)

Sales of non-automotive robots recovered during the last quarter and the record year diverted the attention of analysts:

> "The most interesting result from 2006 is that non-automotive orders reached the highest mark since we've been tracking the data this way. We saw very strong growth in industries such as beverages and tobacco, apparel, wood products, paper manufacturing, printing, machinery manufacturing, and furniture. We also saw growth in food and consumer goods, life sciences/pharmaceuticals/biomedical, and plastics and rubber." (15)

Orders for non-automotive robots accounted for 44% of robot orders during 2006, a 14% increase compared with 2005. The RIA and other industry leaders began focusing their attention on developing new markets:

> "Our members understand that while the automotive industry has traditionally been and remains the largest customer for robotics, changes are occurring in the auto industry that may negatively impact future robot sales to automotive OEMs and their suppliers. Therefore, it becomes more important than ever to find new markets, which is what we're seeing happen." (15)

2007

The start of 2007 proved to be promising for the robotics industry. Robot orders at North American robotics companies increased by 24% during the first quarter, a stark comparison to the bleak performance during 2006. The encouraging growth was the highest during a quarter since midway through 2005. One factor that attributed to the strengthening of sales numbers was an increase in the number of orders from automotive companies and their suppliers. Donald Vincent stated, "Orders to the automotive sector jumped 45% in the first quarter when compared to the prior year, while orders to non-automotive companies actually fell nine percent." Growth remained strong in life sciences, pharmaceuticals, and biomedical, which were up 48%, and plastics and rubber, which grew 9%. While both categories represented comparatively small portions of the entire industry, the growth was a promising sign. (16)

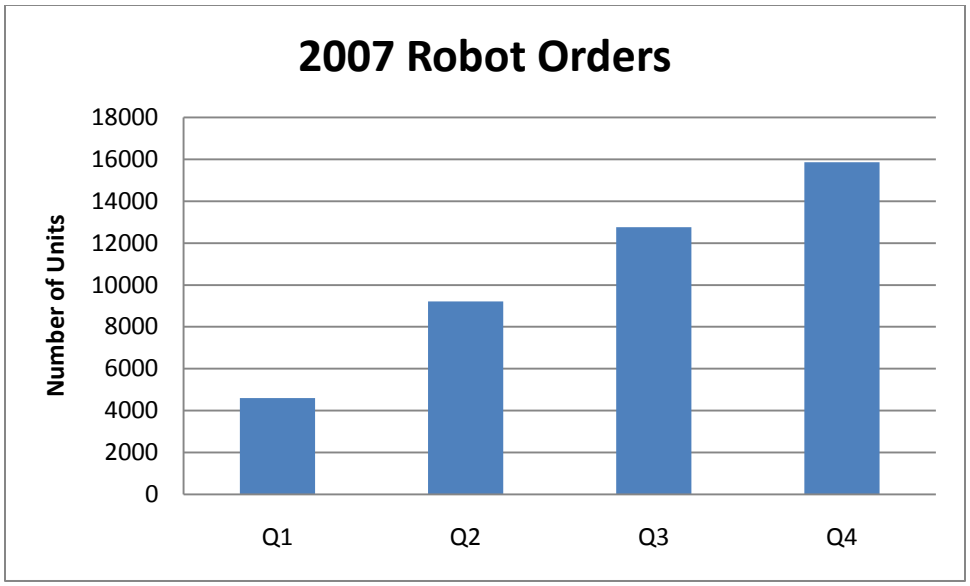


Figure 9 - Cumulative Orders for New Robots from North American Companies in 2007.

The growth continued into the second quarter of 2007. By the end of June, 9,208 robots valued at $525.2 million were ordered by North American manufacturing companies, which represented an increase of 60% in units and 24% in revenue over the same period in 2006 (See Figure 9 and Figure 10.) Although orders from smaller, non-automotive, manufacturers actually decreased 5%, a 76% boost in automotive robot orders was able to improve the industry's performance numbers. Jeffrey Burnstein, Executive Vice President of RIA, explained, "Automotive industry buying patterns are quite cyclical and this year we're seeing the upswing." (17)

The robotics industry also posted double-digit gains in the third quarter of 2007; orders for new robots were up 33%. Åke Lindqvist of ABB Inc. said that sales to automotive manufacturing companies and their suppliers were primarily responsible for fueling the growth of 2007. He noted that sales of automotive robots were up 58% in units and 15% in revenue as compared to the same period of 2006. Lindqvist added:

> "While the cyclical purchases of the automotive industry are responsible for the majority of the gains this year, we are heartened to see that sales to non-automotive industries also posted gains of two percent in units and 31% in revenue through September." (18)

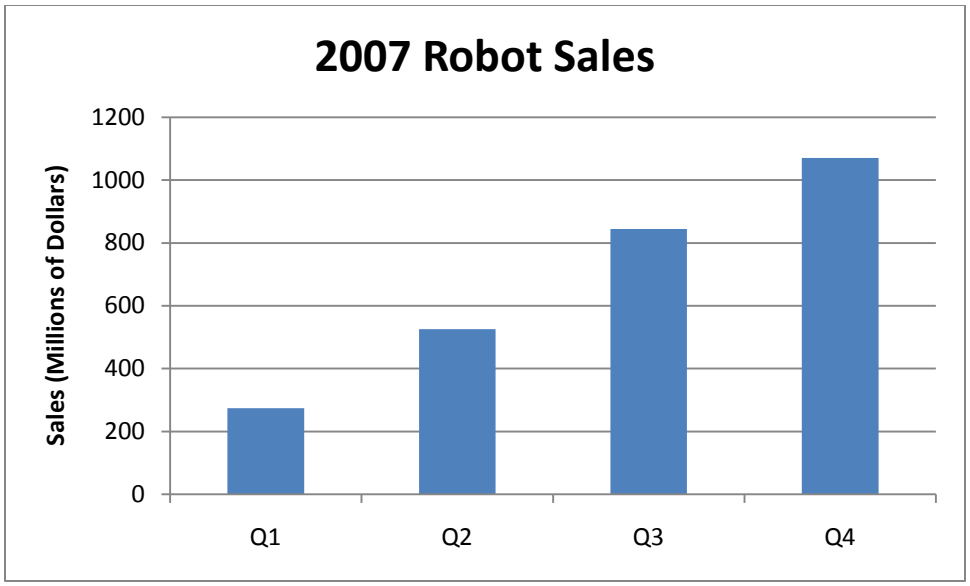


Figure 10 - Cumulative Sales of New Robots in 2007.

By the end of 2007, orders from North American based robotics companies rose 24%, offsetting the deterioration that occurred in 2006. Valued at $1.07 billion, 15,856 robots were ordered, during the 2007fiscal year. Industry analysts were obviously pleased to see the strong growth in 2007, especially when considering the fact the industry saw orders decline 30% in 2006. Lindqvist noted,

> "Most of the growth [during 2007] resulted from sales to automotive manufacturers and their suppliers. In this market segment, which accounted for 64% of all orders, robot sales in North America rose 43%, Orders to non-automotive markets grew less than one percent and accounted for just 36% of all orders. The robotics industry's future expansion depends upon reaching more non-automotive customers and we still have a long way to go. However, we are encouraged by a 16% gain in sales to life sciences, pharmaceutical, biomedical customers and an eight percent increase in sales to food and consumer goods companies." (19)

Jeffrey Burnstein of RIA added:

> "Automotive purchases of robots remain cyclical and our members are quite used to this pattern. For instance, as automotive companies went on a buying spree in 2007, orders for spot welding robots increased 100%, coating & dispensing rose 38%, material handling jumped 14% and arc welding jumped 10%." (19)

2008

Sales of robots in the beginning of 2008 reflected the downward trend of orders from automotive manufacturers that began in the second half of 2007. North American robotics companies reported that orders from North American based companies declined 17% in the first quarter of 2008 when compared to the same quarter of 2007. Revenue, however, rose five percent. On a more positive note, orders by companies not affiliated with the automotive industry grew significantly, an encouraging sign for the future of the industry. According to the RIA:

> "The non-automotive sector saw revenue growth of 116% in Food & Consumer Goods. In semiconductors, electronics, and photonics, unit orders were up 58% and revenue was up 96%. When we come to Metals, orders in both units and revenue were up 50%+. In addition, Plastics & Rubber were up 50. This most likely means that the value-add in the orders to the non-automotive sector are increasing." (20)

Traditionally, orders by the automotive industry account for almost 70% of total orders in North America. During the first quarter of 2008, orders for automotive robots represented only 52% of the total. Burnstein commented, "Welding and coating/dispensing orders showed big declines because these are heavily tied to automotive. Assembly and material handling applications showed gains because many of these applications are also extensively used in non-automotive industries." (20)

By the middle of 2008, robotics industry insiders realized that they were battling more than just the "cyclic" buying patterns of the automotive industry. Orders for North American produced robots fell 23% as compared to the same period of 2007. During the first six months of the year, over 7,100 robots, valued at $528.6 million, were ordered (See Figure 11 and Figure 12.) Åke Lindqvist , Group Vice President of ABB Robotics, and Chairman of RIA's Statistics Committee, noted, "2008 is a very challenging year in North America for the robotics industry and other capital equipment industries. With the economy either in a recession or on the edge of one, manufacturing companies are being quite cautious when it comes to investing in automation. This is especially true in the automotive industry, the largest customer for robotics." (21)

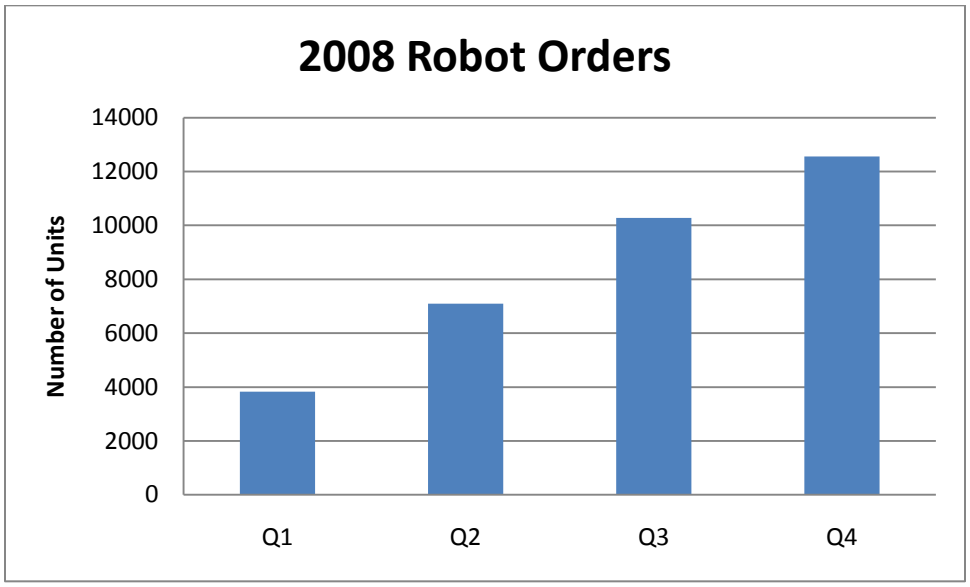


Figure 11 - Cumulative Orders for New Robots from North American Companies in 2008.

RIA statistics showed that orders from automotive companies fell 43% in the first half of 2008. Orders from non-automotive companies continued on their positive trend, posting growth of 23% in units and 16% in revenue. In the past, orders from automotive companies represented a large majority of total robot orders. Due to a decline in automotive robot sales, and a coincident increase

in purchases by non-automotive companies, the percentage of market share for each sector was approximately equivalent. Jeff Burnstein said:

> "The gains in sales to non-automotive companies are very encouraging for the long term . . . we're seeing strong growth this year in orders from the semiconductor, electronics, and photonics industries (+117%), metals (+74%), plastics & rubber (+71%), among others." (21)

In addition, of note was the growth of potential applications in the alternative energy sector such as solar and fuel cell manufacturing.

Orders for new robots continued on a downward spiral through the third quarter of 2008. During that time, North American robotics companied saw a 19% decline in order from American manufacturers. Industry figureheads acknowledged the impact that the economic downturn had on the robotics industry:

> "Given the financial crisis in North America and the especially hard-hit automotive sector, we're not surprised by the overall decline . . . orders from North American auto manufacturers and suppliers, sectors which annually account for more than half of annual robot orders, fell 36% in units and 26% in dollars through September. We don't expect to see automotive orders recover anytime soon." (22)

The only form of encouragement came in the form of continued growth of orders for non-automotive robots. Tammy Mulcahy of ABB Robotics, Chair of RIA's Statistics Committee, explained:

> "Orders received from non-automotive industries increased 15% in units and 10% in dollars in the first nine months of the year. Strong growth was seen, in orders to the semiconductor, electronics, and photonics industries – partly driven by solar - as well as plastics & rubber, life sciences, pharmaceutical, biomedical, and medical device industries. But, non-automotive markets declined in the third quarter, so we'll be watching fourth quarter results very closely." (22)

Jeffrey Burnstein added:

> "[Robotics companies] are quite concerned about 2009, but the financial crisis will surely ease at some point and robots will be near the top of the purchasing list for many manufacturing companies in a wide variety of industries." (22)

The sharp decline in orders for new robots continued to accelerate through the end of 2008. 12,557 robots valued at $894.9 million were ordered by North American companies in 2008; this represents a 21% decrease in units sold and a 16% decrease in revenue when compare to 2007. Jeffrey Burnstein commented:

> "2008 was extremely difficult for our members and 2009 likely will be a very rough year as manufacturing companies throughout the world deal with the global economic crisis. Capital equipment expenditures are slowing dramatically in the automotive industry, traditionally the largest customer for robotics. In 2008, orders from automotive OEMs and their suppliers fell 37% in units and 32% in dollars." (23)

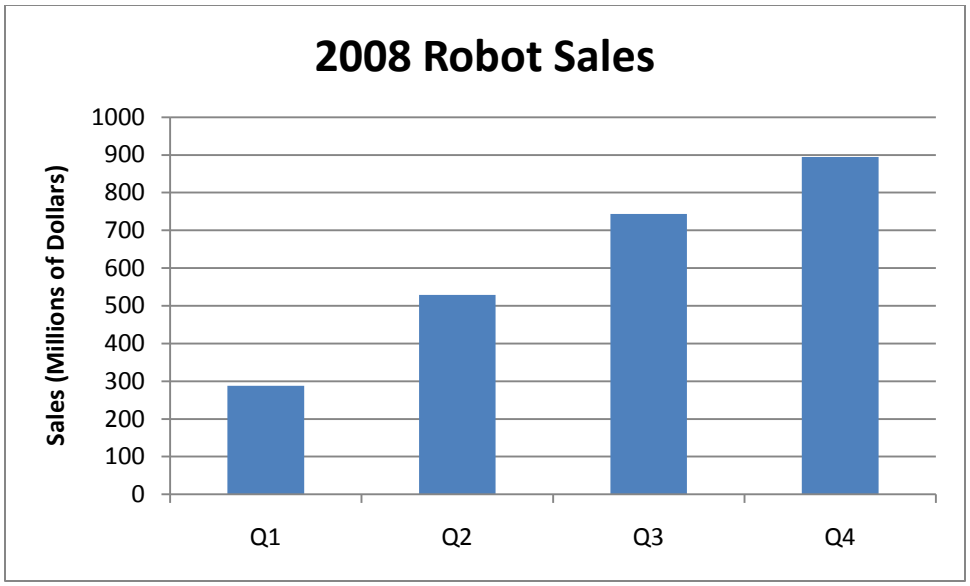


Figure 12 - Cumulative Sales of New Robots in 2008.

In spite of the setbacks related to poor automotive industry performance, Tammy Mulcahy of ABB Robotics offered words of support:

> "In times of rising energy costs and rising environmental awareness, the demand for smaller, more economical, environmentally friendly, and lower cost cars are becoming increasingly important. In order to meet these demands in the short term, the car companies will have to restructure and to speed up development of these types of new models. I am sure the automotive industry will introduce new cars with less consumption, reduced emission, and innovative technology. This will require new automation technology throughout the value chain. Robotics will surely benefit from such investments." (23)

Jeffery Burnstein noted that there was also reason for optimism based on the strong results from non-automotive companies in 2008.

> "Non-automotive orders rose nine percent in units and seven percent in dollars over 2007. The strongest gains came in the semiconductor, electronics, and photonics markets, where units rose 63% and dollars jumped 55%. Plastics and rubber orders increased 39% in units, 12% in dollars, while food and consumer goods saw increases of three percent in units and 51% in dollars." (23)

For the first time since the RIA began tracking robotics industry statistics, the value of orders for non-automotive robots was higher than automotive robot orders. In terms of the number of units ordered, the automotive industry still held a slight lead. Burnstein commented, "This is very important for our industry as we continue to make progress in reaching new customers." (23)

2009

The robotics industry suffered greatly because of the global economic downturn. According to the Robotic Industries Association, sales at North American robotics companies fell 43% during the first nine months of 2009 alone (See Figure 13 and Figure 14.) Industrial robotics stocks have plunged considerably. One major attributing factor is that sales of automotive manufacturing robots fell 44% through September as compared with the previous year. Jeff Burnstein, President of the RIA, notes:

> "While robotics companies are not alone in suffering big declines in automotive orders, [they] are impacted to a greater extent than many industries since automotive customers traditionally account for more than 60% of new robot orders in North America."

A report on The Robot Report read, "Currently the index, when compared to NASDAQ, shows that industrial robotics stocks have suffered by their affinity with the auto industry and with the economy in general." As a result, many robotics companies were forced, to concentrate their efforts

on non-automotive applications. Unfortunately, orders by those customers also fell sharply. "Service robots (the sector focused on assisting people at work and in their daily lives at home) has also suffered with few exceptions: defense-related and medical/surgical." (24)

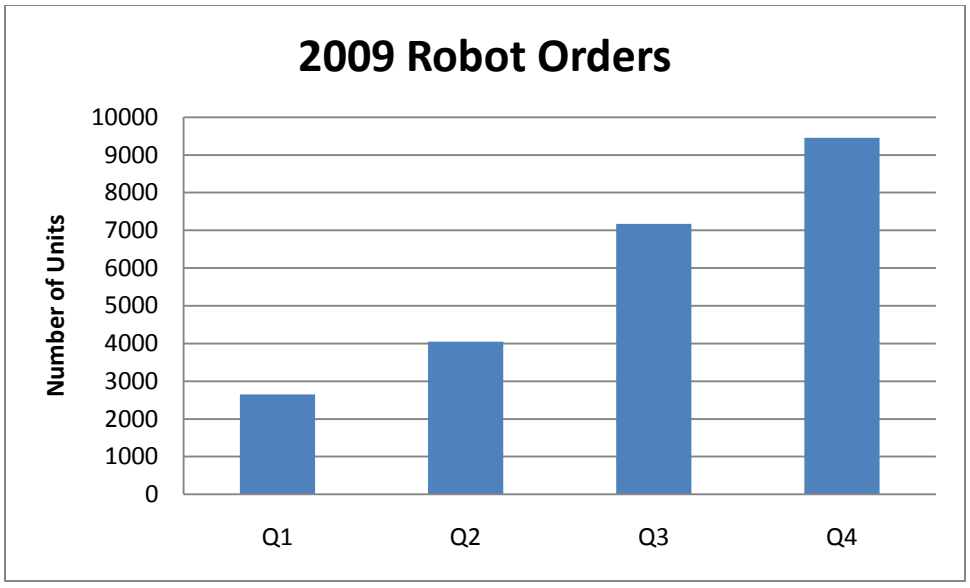


Figure 13 - Cumulative Orders for New Robots from North American Companies in 2009.

Tammy Mulcahy, of ABB Robotics, explains that there are a few positive instances if the numbers are further examined. "Orders from life sciences customers are up 14% through September, [and] orders from food & consumer goods customers are up 12%." In spite of the fact that these industries are relatively small as compared to the automotive robot industry, they hold very strong growth potential and continue to strengthen during an unparalleled downturn in the purchase robotics other capital equipment. In speaking of a 24% increase in orders at ABB during the second quarter of 2009, Mulcahy adds, "While I'm hesitant to say that this means the worst is behind us, we're obviously pleased at this strong upturn." (24)

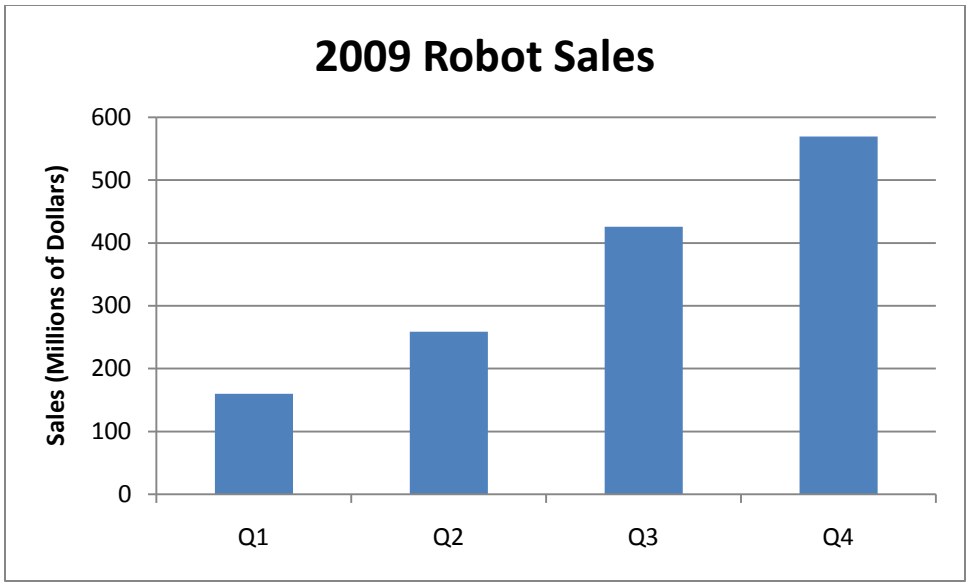


Figure 14 - Cumulative Sales of New Robots in 2009.

Methodology

The Robotics industry has experienced significant growth during the last decade despite the economic downturn over the last few years. Our objective was to create an understanding of the impact of this growth upon the economy and upon students training for engineering positions as well as the implications that an expanding job market and growing applicant pool have on each other. In order to create such an understanding we needed to obtain an encompassing image of the industry as a whole. Much of this understanding came from studying the history of the robotics industry. To obtain a more current view of the industry, we utilized email-polling techniques and researched previously conducted studies to obtain a reading of the modern industry's health. Through the polling of local robotic businesses and the interpretation of business growth rates depicted in older studies, we have constructed an image depicting the health of the industry. From this data, we were able to derive a measurement of the absolute magnitude and rate of growth of the robotics industry. Additionally, estimating the magnitude and rate of change of personnel entering into this specific engineering field provided a corollary to the growth of the job market. Based on these pieces of information, it was possible to create a map of workforce supply and demand within the industry. This allowed for a determination of whether or not the workforce demand would remain ahead of the supply of graduating engineers or whether the supply of workers would outstrip demand; thus causing difficulties for graduates in finding job placements in the not so distant future.

In our efforts to gather the most up-to-date and accurate information, we were introduced to Dan Kara, current President of Robotics Trends.

> Prior to forming Robotics Trends, Dan Kara was co-founder and executive vice president of Intermedia Group, a leading integrated conference and media company focused on emerging information technology markets. He has also served as vice

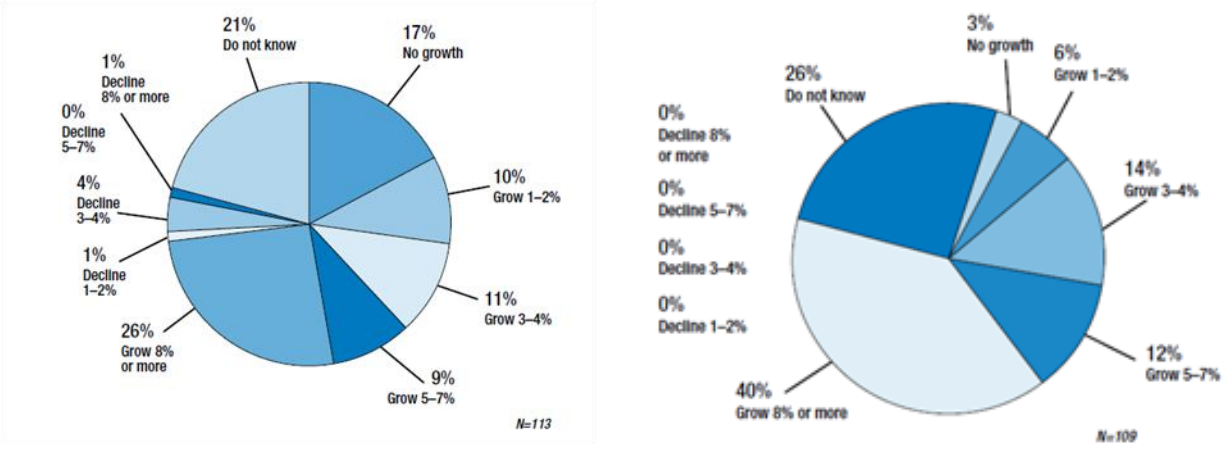
> president of advanced information technology research at Sentry Group, vice president and director of research at Ullo International, and as senior vice president and chief technical officer of Software Productivity Group, an integrated publishing, conference and analyst services firm focused on the enterprise software marketplace. He holds a M.S. in computer science from Boston University. (25)

With his assistance and guidance, were able to learn a great deal about the inner workings of the robotics industry as well as the impact of economic conditions upon the industry as a whole.

Health of the Robotics Industry

Present Condition of the Robotics Industry

Despite the downturn in the robotics industry in recent years resulting from the worldwide economic crunch, the robotics industry has continued to develop its consumer and product base in order to self-innovate and plan for future challenges. As the economy turns around, consumer and manufacturer, optimism is returning. While uncertainty is present, Figure 15 indicates that the majority of polled robotics industries remain optimistic for their current financial returns as well as the outlook. Market trends, as with any industry, shape the course of economic growth, product innovation, and human research interests. It follows from logic that everyone works to support himself and his loved ones. To accomplish this goal within modern society, one typically creates a good or service that is desirable by others in order to generate personal wealth and power. In turn, this wealth and power may then be exchanged for the goods and services of others. Thus in a society, where market trends map the product interest of the general populace, in various goods and services, these trends provide a prosperity guide for most businesses to pursue. It is advisable to study the markets of interest to which many of these trend maps are applied.



Growth Estimates for FY2010

Five Year Expected Growth

Figure 15 - Growth Estimates for FY2010 (Diagrams Courtesy of Robotic Trends)

The robotics sector is comprised of a number of marketable areas in which the industry provides goods. The largest three sub-industries that make up the majority of the robotics industry's business are medical, military, and manufacturing. The field of medical robotics focuses on the use of robotic technology to improve the health and wellness of humanity. Military robotics is used, in a wide variety of tasks including for weapon technology, surveillance systems, medical equipment, and transportation. The manufacturing field focuses on the use of robots to increase the efficiency and decrease the overall cost and time required to manufacture various products on a mass scale. (26)

Medical Robotics includes any robotic technology that aids in the care and wellbeing of human beings. This ranges from the physical to the psychological wellbeing of human beings and includes both emergency care and preventative medicine. Robots in the medical field fill many roles. They act as both intermediaries between patients and health care providers, and in self-guided roles. Robotic technologies are beginning to act as patient-doctor intermediaries in a number of fashions. Robotic instruments in the operating room, like the "Da Vinci" surgical robot, provide surgeons with more dexterity and a steadier manner in the operating room without the risks associated with false movements of the surgical blade, thus improving patient safety and recovery time. Medical Robotics allows surgeons to operate on a much wider patient base since the surgeon can be controlling the robotic tools remotely from the other side of the planet. Likewise, robotic technologies are helping to bring patients and the elderly greater mobility and independence. This reduces the psychological effects of illness on patients and their loved ones by reducing the extra care the family must provide an immobile patient. Robotic technology is filling in other gaps in the medical field. Taking over some of the more monotonous and time intensive jobs without direct human intervention, self-guided robots are bettering the healthcare system by allowing nurses and doctors to focus on the

patients while they (the robots) take care of menial tasks such as paperwork filing, medicine distribution, hospital cleanliness, etc. (27)

The manufacturing industry has been using robots 50 years to aid in the streamlining and development of mass production techniques in products from automobiles to refrigerators. For many years, robotic technology in this sector of the economy has remained relatively stagnant. Much of the robotic machinery used today in manufacturing plants is similar in concept and design to the machines installed 10 or even 15 years ago. This trend was the result primarily of a stagnant yet strong automobile industry, which until only a couple years ago was not only the largest integrated robotics manufacturing industry but also virtually the only integrated robotic manufacturing industry. This coupled with other market factors provided little incentive for manufacturers and robotic developers to pursue newer and more efficient technologies. (28)

Due to market factors, the manufacturing industry has seen little progress in the further development of its robotic workforce. However, with the economic recession and resulting shockwaves throughout the auto and, by association, robotics manufacturing industry, new life has been breathed into the development of new manufacturing robot technologies in order to spread the use of the technology to other consumer products and improve the effectiveness of the machinery overall. As a result, there has been a slow but steady increase in the development and use of robotic technologies in the manufacturing industry over the last year as the economy corrects itself and both consumers and manufacturers become more comfortable with their economic foothold. Research is beginning into a number of hardware devices and software design techniques that are intended, to dramatically improve the safety, reliability, profitability of the robotic manufacturing workforce.

There are still a number of technological challenges to surpass before truly innovative products enter the marketplace. However, research and testing are steadily progressing. (27)

Military investment in robotic technology is the single greatest source of robotic breakthroughs, not only in the United States but also in the world. The United States military has taken the lead role in the development and control of robotic technologies in North America through government funded programs such as the Defense Advanced Research Projects Agency (DARPA). The technological advancements that have resulted from military backed research initiatives have provided a number of devices used for both destruction and humanitarian purposes. The primary outputs of military robotic research has been weapons technology such as smart munitions, smart viruses, and unmanned vehicles, the most notorious type being Unmanned Air Vehicles (UAVs). This is an example of a technology that has allowed us to conduct war while minimizing human costs. Smart munitions have allowed for precise targeting and destruction of enemy strongholds and positions while minimizing collateral human and capital damage. Likewise, electronic warfare is an offshoot of these technological developments based off the premise that wars maybe fought and decided without firing a shot by strictly regulating the control of information to and from enemy forces. Additionally, unmanned vehicles have removed our soldiers from the front lines to reduce the human casualties in war. In addition to combat oriented devices, military funding has helped to develop technologies that will eventually expand into other sectors such as medical and emergency services. One such advancement that is being pioneered, with military funding, is that of nanotechnology and nano-robots. These miniature robotic devices are being designed with a nigh limitless application limit. As construction technologies are able to build devices with ever decreasing physical dimensions, nano-robots have the potential to be used, in medical treatment, hazardous waste cleanup, manufacturing, and countless other field scenarios. Overall, US Military

funded programs have been responsible for the development of the most recent generations of advanced prosthetic limbs, autonomous paramedic vehicles and tools, and a number of other robotic devices. (29) (30)

There have been a number of challenges relating to the development of these technologies and there are further challenges between current and future systems. Some of these challenges include communication, autonomous control intervention, environmental observation and interpretation. These are all important traits in a military setting, for a robot to communicate with the forces it's supporting and provide assistance, , as needed ,in a timely manner, is critical, in a combat zone. Additionally, the ability of a robot to analyze and interpret its surroundings to determine friend from foe in a consistent manner and make tactical decisions, without direct human intervention and control, has developed into one of the greatest tactical uses of the technology in war zones. In this manner, friendly forces can capture a region and leave behind robots to defend positions and supply corridors in their wake without worrying about friendly fire incidents. (27)

In this section, we have developed an understanding for the current state of robotics within the context of its three largest fields. By dividing the industry in this way, we create an appreciation for the advances that have been made in the past as well as the shortfalls that remain within the technology. Possessing such an understanding of the current state of the robotics industry, we can now look to the future with an intention to innovate and prepare.

Outlook Forecasting

Future of the Robotics Industry

Current indicators point towards an upswing in the marketplace across the board from robotic technologies. As the economy is resurging, businesses throughout the military, commercial, and manufacturing sectors are looking to robotic technologies to optimize their future strategies. Even medical related industries and services are looking to robotic technologies to provide a long-term cost saving option to current practices. The primary challenge to accomplishing these aims is the current technology gap between what is available and what is needed in order to fulfill each sector's goal in a reliable and cost effective manner.

The military sector of the robotics field is by far the largest and best-funded area under development today. As a result, it is on the forefront of developing robotic technology that benefits both the military and other business sectors, through the application of military technologies to civilian problems. The military encompasses a large and varying degree of robotic interests designed to protect the country and the men and women who serve in the military. Thus, some techniques and systems created for military purposes may be expanded for use in medical and manufacturing devices to improve civilian life as well. Future military applications of robotics focus on autonomy, fine manipulation of objects, and environmental perception. This technology has numerous applications from smart weapons platforms to medical treatment systems. (27)

In the manufacturing sector, the primary focus of robotic technologies is as a multiplier effect for small worker populations. To create adaptable robotic systems improve productivity across the entire manufacturing industry, there are research areas that still require development and innovation. Robots require a means for self-teaching and adaptation to their environments based on direct

observation of human behaviors and trial and error methods. This in turn will require the innovation of control algorithms and systems in robotics systems that will allow robots to function safely in a work environment co-inhabited by humans. Likewise, this will facilitate improvements to robotic perception and interaction mechanics with their surrounding environment. This perception and interaction can be achieved by developing a new generation of sensor packages as well as high-precision actuators and mechanisms that are light and inexpensive. These packages will require the ability to control and manipulate large pieces of machinery but maintain a degree of fine control and dexterity. Additionally, manufacturers are placing a degree of focus on creating green manufacturing techniques that utilize robotic systems to minimize and manage waste products with higher efficiency and with a lesser negative environmental impact. (27)

The medical sector requires a certain level of development in robotic technology. Robots in medicine require a margin of safety with their human interaction that far exceeds that of any other area. Robots in this field must be able to accurately interpret their surroundings and make actions appropriate to these conditions. This requires a complete and thorough system architecture that can operate in real time to adjust to changing environmental conditions. Incorporated in this architecture must be sensor packages that accurately perceive the environment around them as well as actuators that are dexterous and strong enough to be manipulated, in real time, on both a macro and micro scale, without degrading structural stability. Whether the robotic mechanism, in question, is used, for surgery, medication distribution, prosthesis, or other medical application; robotic technologies must be capable of upholding the highest of medical doctrines, "Do no harm." (27)

Employment

Across the broad spectrum of the robotics related industry, between 2006 and 2009, the performance numbers were below expectations and development of new employee positions

likewise remained low. However, despite the low performance numbers, many robotics companies, such as those listed in Appendix A: List of North-American RIA Members, indicated an expectation for market resurgence within the next two years within engineering fields. This bodes well for the industry as a whole. This is because expansion in the engineering workforce is usually accompanied by expansion of support jobs such as production and fabrication, marketing, and sales.

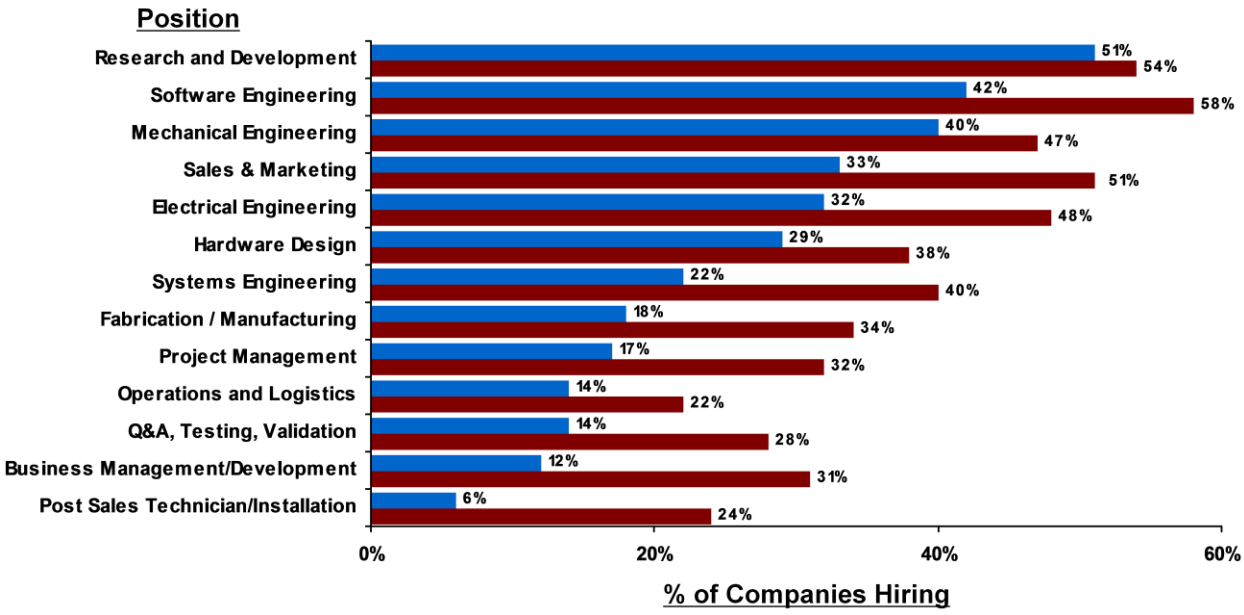


Figure 16 - Areas of Demand (Diagram Courtesy of Robotic Trends)

Among the various positions inside the robotics industry, engineering positions and research and development skills are among the most demanding of skill sets. Due to the stringent requirements to fill these job positions, there is a degree of difficulty in filling these positions in comparison to other skill sets such as sales management and marketing. As depicted in Figure 16, among the most difficult to fill and thus most in demand employee skill sets are Software Engineering, Research and Development, and Mechanical Engineering. The difficulty in filling these positions provides a greater demand for persons with the desired skill sets throughout the market. Thus for any person who can develop the desired skill sets, such as students enrolled in engineering universities and

institutes, the prospects for finding a job is relatively bright. As the industry grows and older workforces begin to phase-out of the workplace, younger professionals from these institutes of higher learning are entering the market place. In addition to educational prerequisites, employers look for their employees to possess certain traits and skill sets. These skills sets help to show an employer exactly the sort of employee they are hiring as well as how well prospective employees will integrate with a pre-existing workforce. (31)

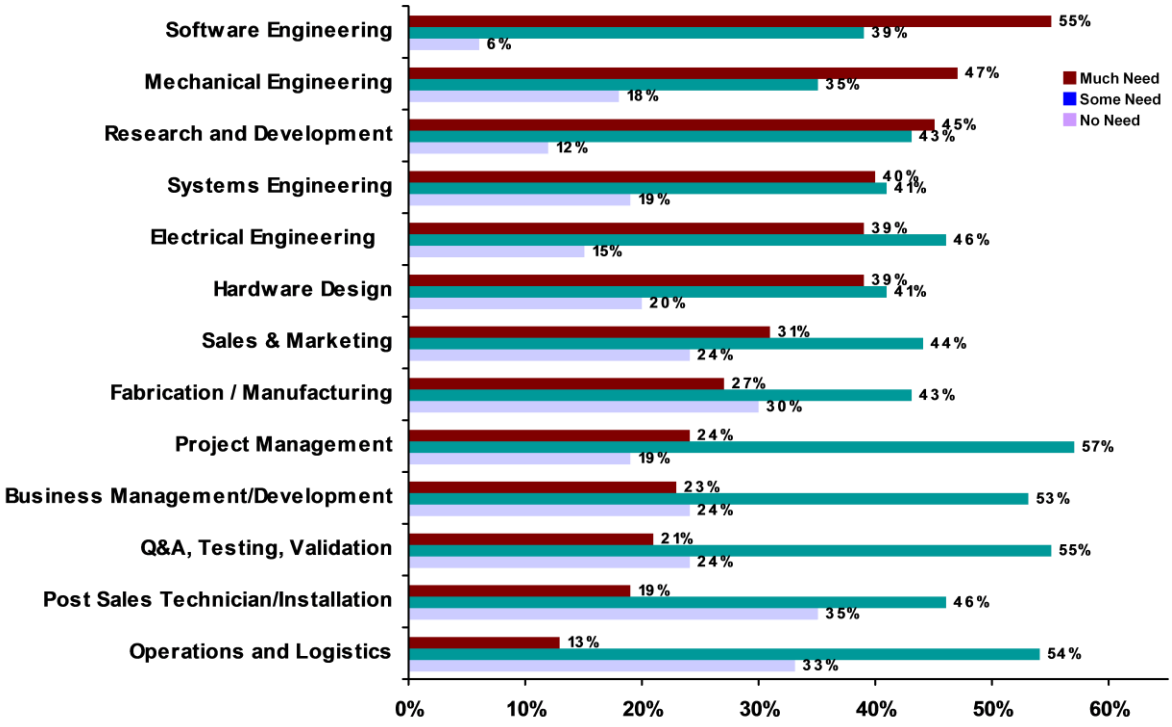


Figure 17 - Demand by Position (Diagram Courtesy of Robotic Trends)

Within a corporation, an employee's skill set is just as important as the educational degree that accompanies him. Employers are looking for critical skill combinations in the employees they are hiring in order to maximize the benefit they receive from new hires. The skill set desired in employees varies by job position, project, and corporation. Research and Development companies tend to hire employees who demonstrate high affinities to problem solving and self-direction.

Businesses, which are more manufacturing and service oriented, tend to place higher emphasis on critical thinking, teamwork, and professionalism/communication skills. Figure 18 depicts a generalized hierarchy of skills valued by employers. Knowing the skill sets valued within an industry or specific company, to which one is applying for a job, can be a critical preparation technique in a competitive market. Knowing and strengthening the desired skills prior to job interviews can lead to a favorable outcome. (31)

Specialization in specific skill and knowledge sets can make one a valuable employee within a corporate structure. However, specialization at the expense of a broad knowledge base is not an advisable career plan. Having a specialization in certain skill sets is only beneficial if that skill set is in demand and there are not more specialists than positions available. If the supply of specialists in a specific skill set ever exceeds the demand for the skill, having a broad knowledge base upon which one can obtain a job and carry oneself until the demand increases for one's special skill is a sound strategy. Obtaining a solid foundation upon which one can learn and grow while in school is therefore a sound strategy towards independence and job security in the future. (31)

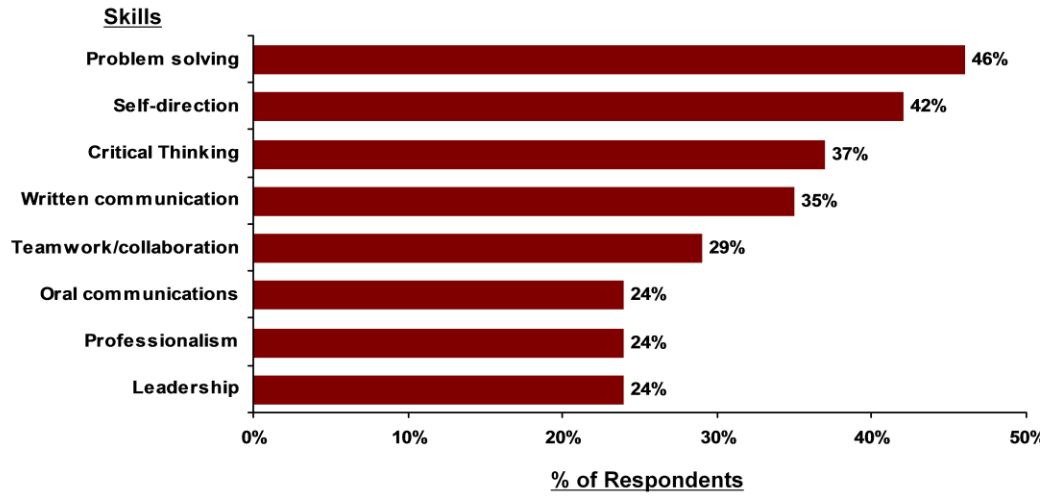
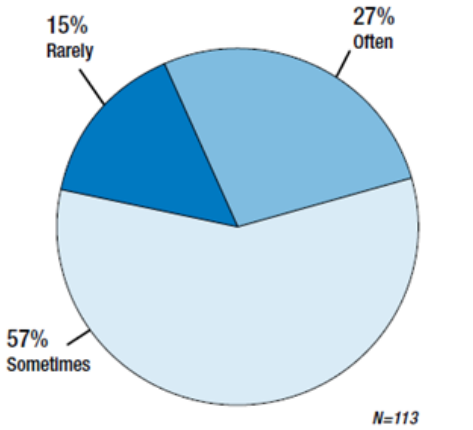
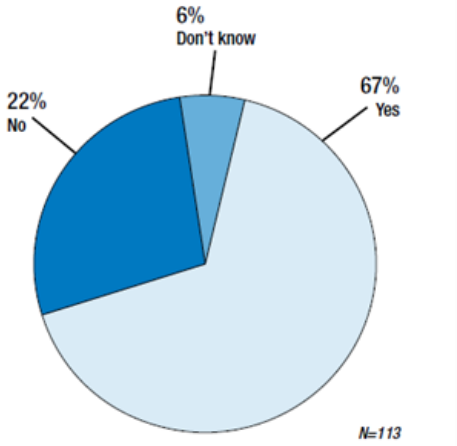


Figure 18 - Valued Skills (Data Courtesy of Robotic Trends)

Having a large pool of educated people from which to draw upon for employment purposes is an important aspect of the robotics industry. As such, many companies take action to promote and maintain the size of their workforce pool. Most robotics companies employ internal policies to promote employee efficiency and retention. Some of these companies likewise look to the future by investing time and resources with area schools and universities to address workforce needs. Figure 19 depicts the level of involvement the robotics industry takes in attracting students towards fields of study that will prove beneficial to the industry upon graduation. Working with educational institutions, companies try to interest students in directing their studies toward high demand job positions. By setting aside resources to donate equipment to universities and run co-op employment opportunities, many robotics businesses influence students to strive towards degrees in engineering and other technologies. It should also be noted that not all companies dedicate resources to future employee programs and thus do not provide internships and the like. As indicated in Figure 20, the

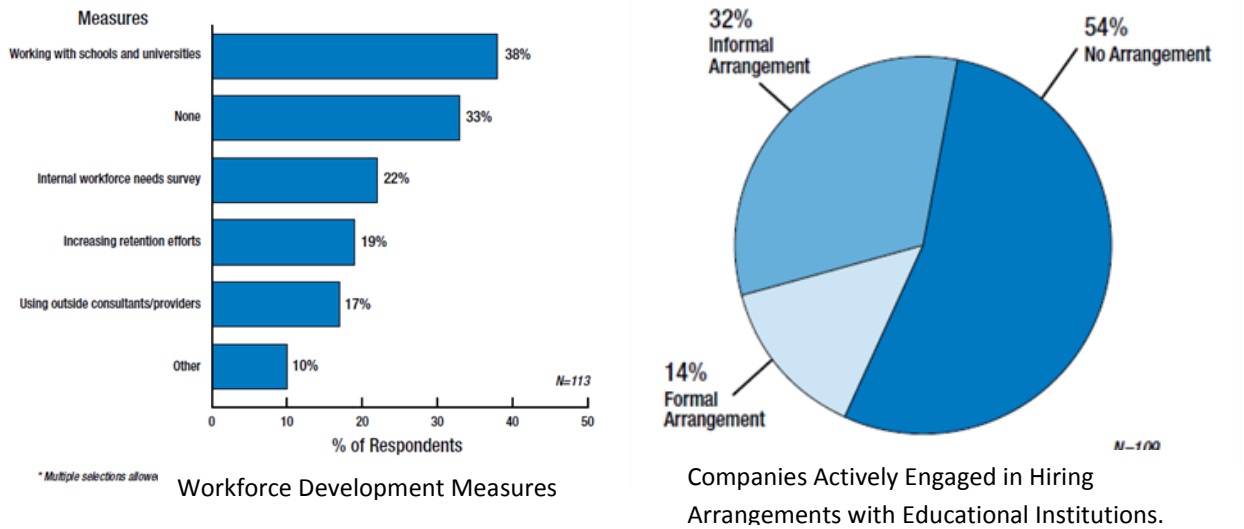


Companies hire full-time directly out of school



Companies Hiring Intern and Co-Op Students

Figure 19 - Hiring Trends (Diagrams Courtesy of Robotic Trends)



Workforce Development Measures

Companies Actively Engaged in Hiring Arrangements with Educational Institutions.

Figure 20 - Workforce Development (Diagrams Courtesy of Robotic Trends)

majority of companies do not dedicate their resources specifically to one activity or another on workforce development. (32)

When it comes to student internships and workforce transition, the majority of robotics corporations provide programs that allow students to get into the workforce early on and experience the rigors and rewards that are inherent in the industry. While the majority of companies do not provide a direct employment option for students graduating from specific institutions, nearly three-quarters of companies polled indicated that they offer internship and co-op programs to students still in school. Of these same corporations, the majority indicated a likelihood of rolling their interns into full-time positions upon the completion of their educational careers. This "apprenticeship" style system helps to alleviate the fears that many students have of entering the workforce before plunging in completely. (31)

It is a common concern among first time employees, who lack self-confidence, that they do not possess the adequate level of knowledge or skills to be hired. This proves to be a false concern. As first time employees settle into their new environment and come to understand their place within

the company, the worry proves to be unjustified. While companies expect a certain level of knowledge and personal skills to be present upon hiring a new employee, one is not expected, to be an expert on the subject on the first day. Companies know that there is a buffer period, in which new employees are brought up to speed. This buffer period allows new personnel to familiarize themselves with projects and integrate into the company's social structure. Many companies go so far as to offer training in certain areas to help get new employees up to speed with specific technologies and tools unique to their business. (32)

Training is a common practice within corporations and it goes far beyond the introductory instruction given to new employees. Employee training is an ongoing process in the business place that provides many benefits to the long-term health of a company. Employee training sessions let employees know that you care enough about them to keep them knowledgeable in their subject areas and retain them as valued workers. This, in turn, provides many positive consequences for the company. Such consequences include, improved employee job satisfaction, lower employee turnover rates, higher efficiencies and openness to adaptable business plans. Another benefit to employee improvement plans is that in explosive technology markets such as robotics, technological advances occur quickly and often. Having employees capable of keeping up with the ever-evolving technology and taking the initiative to incorporate such technology to improve existing projects directly affect the success and prosperity of the company as a whole. (31)

Different companies vary in the scope and breadth of their improvement plans based on the availability of resources and degree of importance placed on different technical disciplines. The hierarchy of importance placed on trainable skills is directly dependant on the products produced by a company. For example, many robotics firms place a high degree of importance on sensor

development and fusion over development of new manufacturing techniques. As a result, such companies will tend to sponsor a greater number of technical training sessions dedicated to sensors relative to sessions dedicated to manufacturing techniques. Employees who take advantage of these company sponsored opportunities to improve their knowledge and understanding are more likely to retain or increase their value to a company and reap the resulting rewards.

Educating to Meet a Need

As of 2005, the robotics industry was estimated to have a market size of $11 billion. That value has increased over the past five years. Companies looking for their share of this market are increasing their technical staff at a corresponding rate of growth. Engineering schools across the country including Worcester Polytechnic Institute (WPI) and Carnegie Mellon University (CMU) have launched robotics-engineering programs and witnessed a growing enrollment over this period. (33)

Between 2000 and 2005, CMU doubled the number of students and staff devoted to robotics; since then the number has continued to rise. At WPI, approximately 60 were registered robotics majors in 2007; that number grew to approximately 150 in 2009 and is expected to rise to nearly 350 by 2011. WPI estimates that robotics majors will comprise nearly 10% of all undergraduates by 2011. As additional institutions like CMU and the Massachusetts Institute of Technology (MIT) institute their own robotic programs, similar growth patterns can be expected. This will provide a steady stream of engineers upon which the robotics industry can draw upon. (34)

Results

Assessment

Despite a lull in the growth of the robotics industry over the last two years, the industry has taken the time to branch out to develop products for new markets and service a wider range of needs. As

the financial panic that has wreaked havoc on the financial institutions slowly subsides, robotics industries are once again seeing increasing returns on their investments into innovative and powerful new technologies. Expanding and growing in the face of economic adversity has poised the industry in a position to increase business and expand its markets to new levels once the economy works itself out.

It is reasonable to ask if the demand for or the supply of robotics engineers is growing at a faster rate. If that question were asked prior to 2008 when the economy as a whole took a turn for the worse, the easy answer would have been that the job market was growing faster. However, the robotics job market has been curtailed by the collapse of the world economy. Consequently, the rate of growth within the job pool certainly outpaced that of the job market. However, this merely made attaining a job within the market more difficult, not impossible, as there the number of applicants had not matched the number of job openings. As the economy recovers, together with the robotics industry, the demands for new robotics engineers will again increase. Therefore, we feel comfortable in our assessment that the industry is on the verge of recovery and that the job market will have an accelerated growth rate placing it ahead of the workforce supply generated by universities.

Based on the evidence gathered and presented in this report, it is the assessment of the authors that the health of the robotics industry is sound and that that the job market within the industry is on the upswing. There remains a high demand for knowledgeable personnel with adaptable comprehensive skill sets throughout the industry. This combined with indicators of a rebounding economy promise a stable workplace for employees and profitable technological investments within the robotics industry.

Conclusion

The development, maintenance, and integration of robotic technologies have become an important aspect of modern life. The use of robotic technologies in the modern world increases everyday as new technologies are developed and put into practice. The call for people with the knowledge and skills set to adapt and apply this technology to societal issues is louder than ever. So too is the response from colleges and universities, who are graduating engineers in record number to meet the demand of modern corporations and enterprises. The robotics industry is once again expanding to fill in gaps in the human experience, from manufacturing to health care. This ever-expanding application of robotics likewise provides an increasing demand for skilled personnel. As such, the outlook for the future of the industry and its employees is bright indeed.

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Appendix A: List of North-American RIA Members

	ABB Inc.	MI	United States	Supplier
	ABICOR Binzel	MD	United States	Supplier
	ACE - Automated Cells & Equipment, Inc.	NY	United States	Integrator
	Acme Manufacturing Company	MI	United States	Integrator
	Adaptive Systems, LLC	MI	United States	Integrator
	Adept Technology, Inc.	CA	United States	Supplier
	Advanced Magnet Lab	FL	United States	Consultant
	ADVENOVATION, Inc.	MI	United States	Supplier
	Alabama Robotics Technology Park (ARTP)	AL	United States	Educator/Researcher
	American Robot Sales, Inc.	WI	United States	Consultant
	Applied Manufacturing Technologies	MI	United States	Supplier
	Applied Robotics Inc.	NY	United States	Supplier
	ATI Industrial Automation	NC	United States	Supplier
	ATS Automation Tooling Systems Inc.		Canada	Integrator
	Automated Motion Inc.	MD	United States	Supplier
	Automated Systems of Tacoma	WA	United States	Consultant
	Automation & Control Technologies, Ltd.	OH	United States	Supplier
	Automation Guarding Systems	MI	United States	Supplier

	Automation World		United States	Supplier
	Axelent Inc.	IL	United States	Supplier
	Axium Inc.		Canada	Supplier
	Balluff, Inc.	KY	United States	Supplier
	Banner Engineering Corp.	MN	United States	Supplier
	Barrett Technology, Inc.	MA	United States	Supplier
	Baumer Ltd	CT	United States	Supplier
	BluePrint Group	VA	United States	Supplier
	Bosch Rexroth Corporation	NC	United States	Supplier
	Buckeye Machine Fabricators, Inc.	OH	United States	Integrator
	Capital Robotics	GA	United States	Integrator
	Central Lakes College	MN	United States	Educator/Researcher
	CIM SYSTEMS INC.	IN	United States	Supplier
	Cloos Robotic Welding, Inc.	IL	United States	Supplier
	Cognex Corporation	MA	United States	Supplier
	Columbia Okura, LLC.	WA	United States	Supplier
	Comau Robotics	MI	United States	Supplier
	Cosmos Corporation		Japan	Educator/Researcher
	Coval Vacuum Technology Inc.	NC	United States	Supplier
	Creative Automation Inc.	MI	United States	Supplier
	Dane Systems, LLC.	MI	United States	Integrator
	DE-STA-CO	MI	United States	Supplier
	DELMIA Corp	MI	United States	Supplier
	Dengensha America Corp.	OH	United States	Supplier

	Dengensha America Corp.	OH	United States	Supplier
	DENSO Robotics	CA	United States	Supplier
	Draka Cableteq USA	MA	United States	Supplier
	Dürr Systems, Inc.	MI	United States	Supplier
	Dynalog, Inc.	MI	United States	Supplier
	EFD, Inc.	RI	United States	Supplier
	Ellison Technologies Automation	IA	United States	Integrator
	Elm Electrical, Inc.	MA	United States	Integrator
	Engineering Services Inc.		Canada	Supplier
	EPSON Robots	CA	United States	Supplier
	Euchner-USA	NY	United States	Supplier
	Factory Automation Systems, Inc.	GA	United States	Integrator
	FANUC Robotics America, Inc.	MI	United States	Supplier
	Farr Automation, Inc.	OH	United States	Integrator
	Festo Corporation	MI	United States	Supplier
	Flexicell, Inc.	VA	United States	Integrator
	Flexomation, LLC	OH	United States	Supplier
	Folding Guard Corporation	IL	United States	Supplier
	Fortress Interlocks	KY	United States	Supplier
	Fox Valley Technical College	WI	United States	Educator/Researcher
	Frommelt Safety Products	IA	United States	Supplier
	Fronius	MI	United States	Supplier
	Genesis Systems Group, LLC	IA	United States	Integrator
	Girard Engineering, Inc	OH	United States	Integrator
	Güdel, Inc.	MI	United States	Supplier
	Halcyon Development	NY	United States	Consultant

	Heartland Robotics, Inc.	MA	United States	Supplier
	High Point Equipment Ltd.		Canada	Supplier
	Honda Engineering North America, Inc.	OH	United States	Supplier
	IAI America	CA	United States	Supplier
	ICR - Robot Sales & Automation Division	MI	United States	Supplier
	IEEE Robotics & Automation Society	NC	United States	Educator/Researcher
	igus Inc.	RI	United States	Supplier
	Interactive Design, Inc.	KS	United States	Integrator
	Intercon 1 - A Division of Nortech Systems, Inc.	MN	United States	Supplier
	Interlink Controls	TX	United States	Integrator
	Invest in Denmark		United States	Consultant
	IPR Robotics	MI	United States	Supplier
	Jabez Technologies Inc.		Canada	Supplier
	Japan Robot Association (JARA)		Japan	Supplier
	JBT Corporation - Automated Systems	PA	United States	Supplier
	JR Automation Technologies LLC	MI	United States	Integrator
	JR3, Inc.	CA	United States	Supplier
	Kawasaki Robotics (USA), Inc.	MI	United States	Supplier
	Kaysafety	OH	United States	Consultant
	KEBA Corporation	MI	United States	Supplier
	KMT Robotic Solutions, Inc. (formerly RPT)	MI	United States	Integrator
	KTS Marketing Solutions	OH	United States	Consultant
	KUKA Robotics Corporation	MI	United States	Supplier
	Lake Superior State University	MI	United States	Educator/Researcher
	Lanier Technical College	GA	United States	Educator/Researcher

	Lapp USA	NJ	United States	Supplier
	Leuze Electronic, Inc.	MI	United States	Supplier
	Lincoln Electric, Automation Division	OH	United States	Supplier
	Macron Dynamics, Inc.	PA	United States	Supplier
	Massiv Automated Systems		Canada	Integrator
	maxon precision motors, inc.	MA	United States	Supplier
	MICROMO	FL	United States	Supplier
	Microvision, Inc.	WA	United States	Supplier
	Miller Edge, Inc.	PA	United States	Supplier
	Miller Electric Mfg. Co.	WI	United States	Supplier
	Mitsubishi Electric Automation, Inc.	IL	United States	Supplier
	MJM Sales, Inc.	MI	United States	Consultant
	MobileRobots Inc.	NH	United States	Supplier
	Molex Incorporated		Canada	Supplier
	Motion Controls Robotics, Inc.	OH	United States	Integrator
	Motoman Inc.	OH	United States	Supplier
	Multi-Contact USA	CA	United States	Supplier
	Nabtesco Motion Control, Inc.	MI	United States	Supplier
	Nachi Robotic Systems Inc.	MI	United States	Supplier
	New London Engineering	WI	United States	Supplier
	Northwire Inc.	WI	United States	Supplier
	OMRON Scientific Technologies Inc.	CA	United States	Supplier
	OTC DAIHEN Inc.	OH	United States	Supplier
	Panasonic Factory Solutions Company	IL	United States	Supplier

	Pandjiris, Inc.	MO	United States	Supplier
	PaR Systems, Inc.	MN	United States	Integrator
	PARI Robotics Inc.	MI	United States	Integrator
	Perfecto Tool & Engineering	IN	United States	Integrator
	Phase 1 Technology Corp.	NY	United States	Supplier
	PHD, Inc.	IN	United States	Supplier
	Phoenix Contact USA	PA	United States	Supplier
	Phoenix Wire Cloth, Inc.	MI	United States	Supplier
	PIAB Vacuum Products	MA	United States	Supplier
	Pilz Automation Safety	MI	United States	Consultant
	Pilz Automation Safety L.P.	MI	United States	Supplier
	Practical Robotic Services LLC	CT	United States	Consultant
	Precise Automation, Inc.	CA	United States	Supplier
	Precision Drive Systems	NC	United States	Supplier
	Premier Tech Systems		Canada	Integrator
	Princetel, Inc.	NJ	United States	Supplier
	Progressive Machine & Design, LLC	NY	United States	Integrator
	ProSafe Inc.		Canada	Consultant
	QComp Technologies, Inc.	WI	United States	Integrator
	RAD - The Robotic Accessories Leader	OH	United States	Supplier
	Reiku \ Drossbach	OH	United States	Supplier
	Reis Robotics USA, Inc.	IL	United States	Supplier

	Remtec Corporation	OH	United States	Supplier
	Rensselaer Polytechnic Institute	NY	United States	Educator/Researcher
	RMT Robotics Ltd.		Canada	Supplier
	ROBOT & VISION, Inc.	MI	United States	Consultant
	Robotic Industries Association	MI	United States	Internal
	Robots in America	MI	United States	Supplier
	RobotWorx	OH	United States	Integrator
	RoboVent	MI	United States	Supplier
	Ross Controls	MI	United States	Supplier
	RS TECH	TN	United States	Consultant
	SAB North America	NJ	United States	Supplier
	Sage Automation	TX	United States	Supplier
	Sandia National Laboratories	NM	United States	Educator/Researcher
	SAS Automation, LLC	OH	United States	Supplier
	Schmalz, Inc.	NC	United States	Supplier
	Schmersal Inc.	NY	United States	Supplier
	Schneider Packaging Equipment Company	NY	United States	Integrator
	SCHUNK Inc.	NC	United States	Supplier
	Sentry Insurance	WI	United States	Consultant
	Servo-Robot Inc.		Canada	Supplier

	SICK, Inc.	MN	United States	Supplier
	Siemens Industry, Inc.	GA	United States	Supplier
	SmartTCP, Inc.	MI	United States	Supplier
	Southwest Research Institute	TX	United States	Integrator
	Stäubli Robotics	SC	United States	Supplier
	Sullivan College of Technology & Design	KY	United States	Consultant
	Syndevco	MI	United States	Supplier
	Tapeswitch Corporation	NY	United States	Supplier
	TEC Automation, Inc.	GA	United States	Integrator
	Technology Brewing Corporation		Canada	Integrator
	Tecnomors SpA		Italy	Supplier
	Tennessee Rand Company	TN	United States	Integrator
	Terra Community College	OH	United States	Educator/Researcher
	The Technology Collaborative	PA	United States	Educator/Researcher
	Thermo Fisher Scientific Inc.		Canada	Supplier
	Thiele Technologies / SWF	CA	United States	Supplier
	Toshiba Machine Co., America	IL	United States	Supplier
	TranTek Automation Corporation	MI	United States	Integrator
	Tregaskiss		Canada	Supplier
	Utica Enterprises Inc.	MI	United States	Integrator
	Vaccon Company, Inc.	MA	United States	Supplier
	Vincennes University	IN	United States	Educator/Researcher
	Vulcan Engineering Co.	AL	United States	Integrator
	Weiler Corporation	PA	United States	Consultant
	Weldon Solutions	PA	United States	Integrator

	Willamette Valley Company	OR	United States	Integrator
	WireCrafters LLC	KY	United States	Supplier
	Wireway/Husky Corp	NC	United States	Supplier
	Wolf Robotics	CO	United States	Integrator
	Zaytran Inc.	OH	United States	Supplier

Appendix B: Interview with Dan Kara - February 5th, 2010

Earley: Today is February 5, 2010. This is Dan Earley and PJ Guill. We are having an interview with Dan Kara today.

Earley: Our project is going to be studying the overall trends in the robotics industry. Looking at the past few years, the present, and what the outlook is for the future. As an aside, we added studying the hiring outlook, what companies are doing right so. As it turns out, we started this project in early to mid-October. I know you were at WPI for the RICC conference in late October. We couldn't attend that, however, we did get CC'd on your slide deck. It seem that you're expertise is right down our alley.

Kara: I was unaware for that you were looking for workforce development.

Earley: Right, that is a newly developed aside that we decided to add to our project.

Guill: . . . about a week ago. It's an area that we saw there was interest in, so we thought we would incorporate it into the project.

Earley: It was important for us to make this project relevant. I'm graduating soon and I have a lot of friends that are as well. If we can write a report on what companies are looking before, it would be beneficial.

Kara: Actually, I have the exact information that you need. We just finished a survey about two months ago in workforce development issues in the robotics industry. Let me go see if I can get a couple copies of that.

Kara: The sample size is anywhere from 250 to 275 depending on how many people answered the questions. It might be a little below that range depending on how they answered it. We specifically went in and asked one group of companies . . . our lists, we have a lot of robotics lists we have been doing. I'm not sure if you are aware of the events we've been doing? We do Robobusiness, Robot development, robonexus, CES robotics tech zone. So we have good lists into the robotics space, not only people building robots, which are actually a pretty small number, but, people building enabling technologies for robotics and also people using robot.

Earley: so from the customer side as well?

Kara: Right. So what we did is ask those three different groups about a number of questions there, you can see them. What they're predicting now and what they expect in the future. Now, you can use that data as long as you cite Robotics Trends and then what I can do is to send you the slide set as a pdf. It will make it a lot easier for you to incorporate any graphics into the article.

Guill: That would be excellent.

Kara: So as long as you cite us, the graphics, Marol, they might have a graph 1 thing or something.

Guill: So do you want Robotics business review or robotics trends?

Kara: Robotics Trends. You can cite the issue if you need to cite it. So that you can just read through it because we basically went in and we asked people what the skill sets they're looking for were.

Guill: Did you focus on any specific sides of the business like the larger corporations?

Kara: We give you a breakout of both geographic, it's mostly, we limited it to the North American marketplace. So we broke it out by geographies, we broke it out by vertical market segment, number

of employees, gross revenues. So then asked them how did you expect these to grow, expect these to decline. How many people they've hired now, how many people they expect to hire. Then we also looked at positions, working with universities and other schools. It's pretty self . . .

Earley: It sounds like it answers a lot of the questions we have actually.

Kara: We ask some soft stuff as well. We asked about educational level, what they expect of people coming out of school, technical training that you do once you got into a place. I think there is some non-technical as well. So a lot of that will be right in there. So what I'll do, I'm going to need both of your email addresses. Let me get you the slide set to that, so you have that in PowerPoint.

Guill: That would be great, we really appreciate that. Just so we don't take up too much of your time today, I just want to make sure you have enough time to meet with us.

Kara: Ya, If we could do this in an hour . . .

Earley: That's plenty of time.

Kara: There's actually a meeting going at 11, but it's mostly sales stuff.

Earley: All the boring stuff . . .

Kara: It's not really what I get into. Actually with this business, they're trying to just have me focus on content and research. The company was bought in 2007. At that time they've been trying to have me focus on what I do well and have other people handle that business related stuff.

Earley: Well that actually leads us into our first question. How did you get started in this? What interests you in the robotics industry?

Kara: Sure. Well I'm a technical guy. I have a master's in CS from BU. Undergraduate degree in biology. I've been in a number of media start-ups. My background was actually in neurobiology, I was in a PhD program. At that time, this was mid-80's, going into computers was not like accounting like it is now, it was like the thing. You could make a lot of money very quickly. I was in a couple of start-ups, we did ok. Then I enjoy the research and the writing side of it. A friend of mind and a couple of other people did a couple of media start-ups. So that's market research and consulting, publications, and conferences and events. There's this common thing to do in the Boson area. We don't have a lot of natural resources. We have bad weather. So we have to focus on what we do well. We did an number of those things. We grew and sold one business and then the same partner I had, we had about sixty people and we sold that company. Then we did it again, we created a company called Intermedia Group which did market research and consulting. So we cut on very cutting edge things so actually the things that seem pedestrian or basic technology at one time, like the launch of Java with Sun and Next with Steve Jobs, we helped them with that. There used to be that thing called Karo rhyme or enterprise Java, we would explain it to business people and big banks in New York. We grew that company up and sold it. I had been looking at robotics for about 5 or 6 years and there was just not enough to carry us there. Even in the military space there was nothing in 2000 or 1999. So I took a year off to find myself. I went to Japan and Korea, took up painting, spent time with my family. We launched RoboticsTrends in 2003 and launched our first event, emerging robotics technologies and applications conference in 2004. That and then robonexus, which was also brought in consumers. We brought consumers and the military together which was really strange; a lot of people though. Had everybody there. We would have FIRST at this, and bot-ball, and battle bots IQ. That was a consumer event, which I really like. Then we Robo Business which is our very buttoned-up business oriented event. You would really have someone from the military standing next to someone from Hasbro, over cocktails. That's the way we planned

it. There were these isolated groups, there were the academics, there was the military, the industrial robotics, and no one was talking with each other, they had their own events. The academics had their own events, but they didn't talk about business. The military is very inwardly focused. So we just brought them all together and we ran that event seven times, back and forth between Boston and Pittsburgh for the reasons you can imagine. Then we also launched a more technically-oriented event call Robo Development, which we run in Silicon Valley. We don't focus on prototypes or hobby kits, these are people commercial robots to make money. It might be a smart toy, a UAV, or a surgical robot, but everyone is in there to make money.

Earley: What about academic robots, projects by schools like CMU or MIT?

Kara: We did, CMU, WPI, they would all be sponsors. Basically they were looking to get students, graduate students, or to meet with larger companies that might invest in them or give them money. That's the way we did it; very, very different. So I grew that up and bought my partners out in 2006; they wanted to go off into the wireless world because they could make more money that way. I enjoy robotics. At the time I didn't know anything about mechanical engineering, I'm an electrical and software guy primarily. But the neurosciences stuff maps very well into it, particularly AI and a lot of other things. And no one was really looking at it. And if they were, you get quantitative data from the mil-aero guys for UAV's, the industrial robotics sector is so that they have people to do this, but they don't have people looking that the smart toys marketplace, or autonomous transportation, in a business way. So that's what we decided to do. Now we have Robotics Trends, which you guys should sign up for, Robotics Business Review, there's a free newsletter there, they try to sell you stuff, but there's a free newsletter there. So now, this year we are launching virtual events, which you should sign up for because they're free. So literally, and they're having three keynotes, we just confirmed the keynote from NASA JPL who's going to talk about autonomy in

systems. There will be a business-oriented track, and a development-oriented track. They will run with some interweaving. The thing is, once the talks are done, they stay there for 90 days. At robobusiness, we would run five tracks. People can't be in five places at once, at least not yet. In this case, they can attend when they want to , there's a full exposition floor on the first day you can go in an actually as people there. Eventually is will be more like Second Life, it's not like a webinar anymore, it's the next generation thing. In 2011, we'll go back to more of the physical events. Because this year we're holding off physical events. It's really really tough.

Earley: Is there a reason?

Kara: Well one, it's the next thing to do. Two, we're getting feedback from our customers asking if there is a way to do this more cheaply. At the same time, we know, particularly with robotics because you have to have a physical robot in the room. The Koreans and the Japanese, for their events, they do them every other year. We were just doing our every year. This year we said we're going to try this new thing, we're going to focus on the content. So when the company came out, we started doing events which is kind of ass backwards. You really need to get a name for yourself, do serious research and content, and then from there everything kind of flows. We did it the other way around because the partners I was with at the time, these are ruthless business people, they could care less about the technology. My job, and I partnered with the same guy over three companies, is to just find the next big thing. Then he would handle the business side, and I would handle the technology and content side and that's how we did it. Is was like an old married couple, eventually we just started bang heads. I wanted to focus on one thing and he wanted to keep moving.

Guill: Did it feel rushed?

Kara: Our model was to build these companies up really quickly and sell them. That was it pretty good model, it worked three times. In this case, I'm now 52, I didn't want to keep doing start-ups.

Earley: Correct me if I'm wrong, but start-ups take a lot of energy right?

Kara: Right, it's a killer thing to do. If I was to do another start-up I would make sure we had more money to go forward with. We were better positioned, after selling three companies, to do that. So I'm focused on creating really high quality content that you can't get for free on the web. We're not perfectly there yet, we're having problems getting writers. There're analysts, who are all in IT, the writers are just writers. We need something in between, we need deep robotics expertise, business expertise, and some technology expertise and be able to write from all three aspects. So that's how I got here.

Guill: Along those lines, one of the questions I had was in terms of the industrial robotics and the rest of the robotics industry that has developed since. What is the difference or breakdown between the two in this state of age? There are a lot of people who can say they are industrial robotics engineers and know in general what they are supposed to do there, but then when you look at the rest of the field there is still a lot of confusion as to what exactly the robotics industry covers.

Kara: Robotics Trends, the evolution of the company, follows that dichotomy. We first launched Robotics Trends, we had robotics trends website . . . didn't have Robotics Business Review at that time, we decided to forgo the industrial robotics market segment. That marketplace was tied up already, they already had people to do what we did. It also seemed kind of primitive. At the time, even in 2003, they didn't have PC front-ends to program these things, that's where they were. And everyone had their own programming interface. It was very primitive. We said, you know what, we're going to focus on mobile intelligence systems, that's what we're going to do. Over time we've changed that. If you go to Robotics Trends, you'll see a tab there for industrial robotics. We just finished a piece for Robotics Business Review where we talk about the new opportunities and it's about 20 pages long. About new opportunities in the Industrial Robotics sector. Well Industrial

Robotics is getting a lot more sexy now. We are moving away from these fixed platforms to do very programmatic . . . they're not even vision-based systems, most of them. Now you move into vision-based systems. Now it's getting even better, for example . . . we tried to second guess what Rob Brooks is doing after he left iRobot. It's clear that he's focusing on industrial robots, but industrial robots of what he calls "Wal-Mart type" assembly. These things are not only vision based. They're touch based as well. If you think about it, if there's a box of bolts next to you, if I go to grab it, I don't need to think about moving to some sort of X,Y coordinate, pick it up. I don't even need to see it. All I need to do is reach over and grab it. So now there's a number of people developing this: Heartland Robotics, Rob Brooks . . . develop humanoid robots that work in close approximation with humans . . . arms are all back-drivable. There's a whole pile of other smart software in there for safety. They're designed to work in conjunction with humans . . . let humans do what humans do really well and let robots do what robots are well at doing. Maybe handling things that are more dangerous or are more repetitive. The manipulations capabilities right now are not nearly as good as what a human hand can do, but they are much better than they were even in 2004. So when I see things like what Barret is doing, what Heartland is doing, all these other guys, it's clear what this is moving in to. An in areas of warehouse automation, or pick and place, these things are becoming very mobile and intelligent so companies like Kiva systems, here in MA, are just mind boggling. What they've done is applied autonomy through a lot of smart software. Some of this stuff isn't even that difficult technically. Some of it is more difficult, they're just thinking outside of the box. Right now, to get back to your question, I'm pumped about industrial robotics in a way that i wasn't even 5 year ago. I thought it was a dead end. I knew it wasn't a complete dead end. I'd go to these shows, it was basically welding a painting. Now you go to them, there are robots acting cooperative. There's still not a lot of intelligence. The autonomy is very limited but it's moving along.

Earley: That's one of the questions that we asked ourselves when we started this. Are we going to be able to put a name or a direction on the trend on the entire industry, or are we going to be able to say that each individual sector is going in its own direction. For example, if you talk to some ABB robotics, they'll have their welding robots and their painting robots, but they're handling food now, they're shearing sheep now. That's exciting stuff.

Kara: Actually, I got another publication I should give you guys. We just did a piece on the industrial robotics sector. How this marketplace is expanding. We covered things like if you're a big existing industrial robotics vendor, what do you do? Right now, 95% if that marketplace is tied up in automotive, electronics manufacturing, and large enterprises, so they haven't gotten the small guys. So there's a whole pile of new units out there that want to target SME markets. They need cheaper robots, they need robots that are easy to set up, they can't afford to have robotics engineers on staff. There's a whole movement towards these functional workflow driven robots. So there's a whole pile things of things summarized there, basically laid out as a taxonomy. Let me get a hold of that piece for you. In terms of overarching trends, if you want the really big picture, I just put the final edit on something, and it's a little high level, but it's autonomy. Everybody, it doesn't matter if you look at the big sectors, industrial robotics and service robotics . . . break those down in personal service robotics for home use purchased by individuals, service robotics purchased by industries, anything from surgical to military, everybody is looking to make these things more autonomous. That's the big overarching trend at this time if you were to look for one. It just maps into everything. Even the military, but not for reasons that you think. You would think it's to make these things more functional. It is, but for a lot of the work it's actual cost reduction, which you don't think of in terms of the military because it seems as though they have an unlimited budget. They will tell you that actually these robotic systems are costing us more manpower. you look at all these weapons systems, it's a huge amount of money. But all of their big money is in personnel. And what goes on after

these people retire. My Dad was in the service for 20 years, he's taken care of. They can't afford that anymore, they're cutting back. But it's health care, they can't afford their health care costs. What they want to do it ratchet down the manpower. They get more functionally, more capability, more mission capability, but it's also come down to the fact that they just need to reduce cost. Also the other focus for the military is not so much what they can do to replace people, but what to robots do better than people. A lot of the focus has been on sort of like what the war fighter does. Now the emphasis is on what can these things do that you could never do before. If you were to look at that overarching trend, I would think that it's in the area more autonomous behavior.

Earley: How much of that do you think has to do with the economy? You mentioned the smaller businesses are looking to save money. Would you say that that is directly related to the economic crisis?

Kara: Yeah, I think a lot of it has to do with that. If you look at the big industrial players, they got killed by the automotive industry as is scaled back. What do you do? This was an industry that even as it was struggling, they were adding systems on there to increase quality, to get productivity throughput, and cut down on their manpower costs. That whole marketplace not only was struggling, it died over the last year and a half. So those revenues went away. Al lot of it is driven by the recession. It's like, we need to go into new market segments. They had to innovate. The recession in a lot of ways is driving a huge amount of innovation. If these people were making money hand over fist, they would never look to make more functional robots that could work for smaller businesses because that is a tough marketplace. These people don't have as much money, the sales are harder, they aren't buying $20 million systems. They're looking for cheap, inexpensive robots. That's a good example of how the recession is driving this marketplace. Also, a lot of it has to do with the fact that this is where you start getting the perfect storm in terms of technology

capabilities, political will, which is really important to do things like bringing manufacturing back to North America. We're still the largest manufacturer in the world, that kind of gets lost on people, but we still are and in fact, its growing. There's certain segments that have been clobbered, but for doing this cheap manufacturing, we can use automation to compete with these other areas now where they have basically cheap labor. And frankly, you see these countries, we see China now, the manufacturers are moving inward from the coast because the people who live on the coast are one generation into doing pretty well. They want to make more money. So now, the manufacturers are looking off the coast. They're looking at places like Africa. That's how strange it is. That's how quickly it turns. One time, cheaply made manufactured things were done in Japan, that kind of went away. They focused higher quality stuff. Then is went to Korea, Taiwan, Singapore, and now it's over in China. Then you move over Vietnam, you move over to India, and then to Africa. But there are costs involved with that. There's issues related to quality, there's issues related to shipping. The largest market is still here in the US. why not manufacture here? So I had a conversation with some of the folks from LEGO. They moved their production back to Denmark, or Sweden, where they're from and they automated it. If they just look at the total cost, and it's not just how much plastic you can dump out, they automated everything, and their costs are reduced that way. The recession is driving, yes we've been hurt, but it's also the right thing to do.

Guill: so you would you say for the robotics industry, when the economy first started to tank, and it was primarily the bank systems, it wasn't affected as much, but when the auto industry, one of its main outlets, went out, that's when it started hurting.

Kara: Right, in the industrial robotics sector. Some sectors are still doing really well. If you look at military primarily, and if you look at things that are not tied into robotics as most people understand them, like adding more autonomy to your car, it's doing well there. So this is enabling technology, so

they're not robotics companies per se. Then other areas are certainly in health care robotics. Even through the rough times, companies like Intuitive Surgical, which are modeled on the pure West Coast BC model, are doing well. Some of the other ones have struggled, but a lot of that has to do with FDA approval; the medical marketplace is very tough. But there's another area where they're just moving to add more autonomy, even to surgical robots. I know that sounds strange, because you'd think they're very limited. But if you see these, they are real robots, they're not purely tele-operated. If you're cutting, and it's supposed to be soft tissue, and you hit something hard, before that surgeon has time to back away, that robot has backed away. So people say, it's not really a robot, he's basically moving his hands and making it virtual, that's not the case.

Guill: That's interesting, I wasn't aware that they had those capabilities.

Earley: So going to the customers, you mentioned LEGO, how are hard is it to convince customers that the right thing to do for their operations is to make everything autonomous in this economy.

Kara: Well it's tough because there's an upfront capital costs.

Earley: It's fairly large correct?

Kara: It can be really large. Particularly for surgical systems, they're going to go in at over $1 million. Now the latest version are like $1.4 million for the da Vinci surgical systems, and then you start getting the ongoing maintenance costs. There's the training, and then it's like software companies, they make a little bit of money on their software sale, and then it's the upgrades all the time that you have to pay for. And with da Vinci, I don't know if you knew this, all of their instruments are proprietary. They get disposed, and you get new ones, and you're buying those instruments from Intuitive Surgical. That's when the guys on wall street were evaluating this company, it's the individual sales that they're looking for, and those are growing, but it's also the follow up sales. Now

they follow that, because hospitals now are kind of pulling back on the inventory, so if you go into a drug store, they'll have bags of candy, they used to be ten deep, now they're 2 deep. The hospitals are doing the same thing. So the inventory they've pulled back on. They're still buying systems, even multiple systems per hospitsl, but they're pulling back. Some of the ways that they're marketing the Intuitive Surgical device, is not only by virtue of the fact that you can get people out the door quicker, they want to keep filling hospital beds and have turnover. This is a business for these guys. Now they're looking at it as a marketing tool.

My parents are retired in Florida. They have flyers sent to their house saying, "We do surgery using robots," basically written for an 80 year old and basically that's what they're saying. So now it's a marketing tool as well, it's a way to get young surgeons who are coming into the marketplace who want to be on the very cutting edge. So there's a lot of other things that are driving sales. Basically it's all driven by the dollar. Some of it's more soft, in terms of we can use this as a marketing tool, we can use this to attract the best surgeons. Some of it is hard, we can get someone recuperating from a surgical procedure out the door in two days, so you can fill that bed again. And then the insurers look at it, we they're doing this stuff at home, this is cheaper, that's what is all comes down to, it all comes down to money, that's why this is robotics business review as opposed to cool robotics technology.

Earley: Have you gotten any feedback from companies that are replacing their workforces with automated robots? Have you gotten any feedback from the people being replaced by robots?

Kara: You always hear that it's held up as a straw man, and i guess in the common understanding as to one of the reasons that the US fell behind particularly in industrial robots. I mean we invented them, the first companies were here, and then they were either purchased by Japanese companies and now for industrial robotics, it's basically Germany and Japan and now Korea. Maybe with these

new ones that are being developed in the states, the more fine manipulation robots, they'll stay here. And it was always thrown out that people didn't want to be replaced. The unions got involved, there might be some truth in that. That's always been the other side of moving to automation. That's where the term luddite came from. I do hear that. I don't know of any mass replacements due to robotic automation frankly.

Earley: Do you think it will be more of a gradual process of replacement? You'll see a shift in the training of the workforce. Rather than doing the actual manufacturing, their working on the robots.

Kara: Right, they'll be doing the programming. I think the people who are doing the really boring, repetitive work will be replaced. If you look at the automotive industry over time, those welds were done by individuals at one time. Now they're done by a robot. They're done more consistently and with higher quality. So it's one of those things that's persistent and doesn't go away, that in fact, bringing in automation is going to result in mass lay-offs. Frankly it almost doesn't matter because automation is coming for the reasons that we just discussed. So hopefully these people that need to be retrained are just going to do it, it's just the way that it is.

Right now if you look in hospital pharmacies, a lot of that automation is done by a robot. It used to be done by multiple people, now you might have one person, and you have a system that works more consistently, and drugs don't get stolen, people don't get the wrong prescriptions. That's just a tough one, because myself, and probably you guys, are not going to be stuck in that situation where you did that type of work that was replaced by a robot. When tough economic times come, people tend to get very solidified in their beliefs and in view of those beliefs. I see out in the Midwest that people are very upset. They say, "My grandpa did this, I did this." They need to understand that they have to learn something else. For example, I'm starting to learn Japanese because I don't know what's going to happen, I'm in the robotics field.

Guill: Trade skills aren't working out as well as they used to.

Kara: Right and it's tough because I can't put myself in their shoes. I moved into robotics basically because I was bored with IT and I needed something else that was a little more interesting and a little more forward thinking. IT at one time was that. For my son, and probably for you guys, computer systems is in a large way like accounting. It used to be really really cool.

Earley: It's assumed you have those skills now.

Kara: Right.

Guill: Earlier you mentioned that this focused primarily on the North American market area. Have you done any research on the world wide aspect at all? I know it was in the news recently that South Korea is opening up foreign trade markets now so I wasn't sure with that and with Japan and other robotics oriented countries if the growth was similar to that of the US?

Kara: I have looked at it. Most of the stuff I look at comes from the RIA, which does they quarterly publications of the North American marketplace. If you want to do worldwide, you have to look at the International Federation of Robotics. So they have research that's out there as well. You can't get the full research reports unless you pay for them, but they'll have a press package that highlights the number of robotics units sold throughout the world. You might not get the breakdown that you would get if you bought it, but after 10 slides on industrial robotics, they'll have one talking about service robots all thrown together. They need to expand on that a little. I think what you'll find from the RIA is that sales have gone down. We'll see that that's going to have to pick up, people are going to have to replace these things. The average life on an industrial robotics system is 12 years, so we know that at least 12 years from now people will be buying more robots.

Earley: So you think that the right now the overall trend is down but in the near future, it will recover?

Kara: Automation is coming. Autonomy is coming. That's just going to be the way it is. I'm very bullish on the marketplace. It's slower than the other companies that I've had in IT and computers. Those things ramped up very quickly and sold. One of them we only had for 3 years. The other was only 6 years. I've been in the robotics industry since 2003 and we haven't even grown it yet. This is still the early time. We're adjusting our model a little bit. It doesn't help that the media segment has been hammered. To think that big newspapers and magazines are just going away, the web it just killing everything, people aren't buying anymore. People aren't advertising anymore. Look at the Boston Globe, the Sunday paper, its all been hit, expect for maybe the bridal magazines, they just seem to plow on. Actually, there was only one month in the history of publishing where ad pages grew that blew out the bridal books and that during the height of the first internet boom. Publishing is struggling; we don't know what the model is for this. We're focusing on business to business high quality content. We need people that can speak to the academics and to the business people.

Earley: Do you see yourself doing more soft media versus the hard copies?

Kara: Well if it was me, I vowed never to do a printed publication again ever in my life because there is just so much extra work to it. But the guy who bought the company believes this is a model for some class of people that still want to be able to put something like this in their briefcase. This is the model that I'm looking for, again, very business oriented. When I went to graphics people, they came back with a glossy publication. We're going to use two or three colors, cold colors, because that's the robotics industry. We're going to a different readership. I'm still struggling with some high quality content. I'm about ready to send Mike Gennert a comped subscription, so you should talk to him. The website has a lot more than the printed publication.

Earley: Well it looks like you've answered all of the questions we've had to ask. This publication answers all of our hiring questions. You've given us a lot of great information. Thanks for your time!

Appendix C: RIA Industry Sales Data

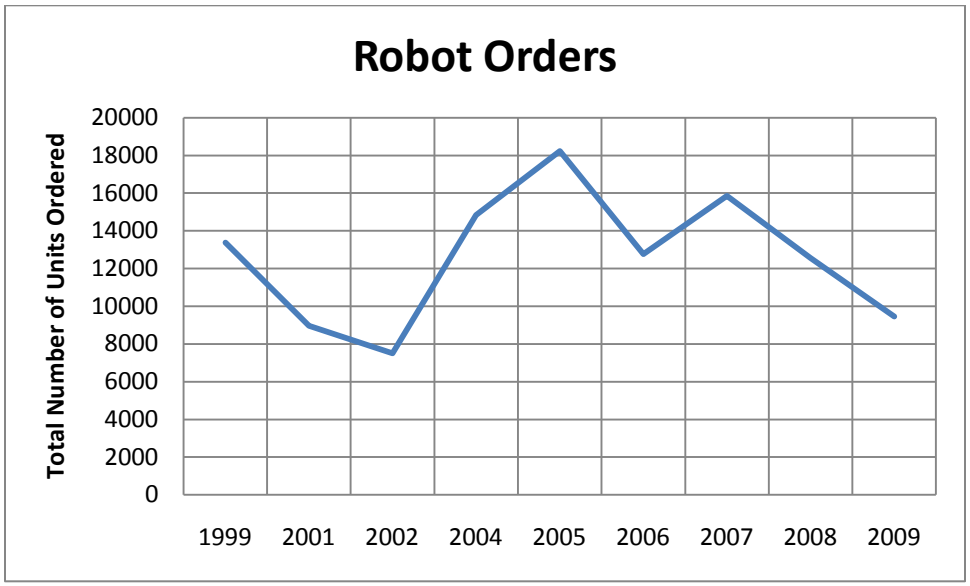

Figure 21 - Total number of new robot orders in North America from 1999 to 2009.

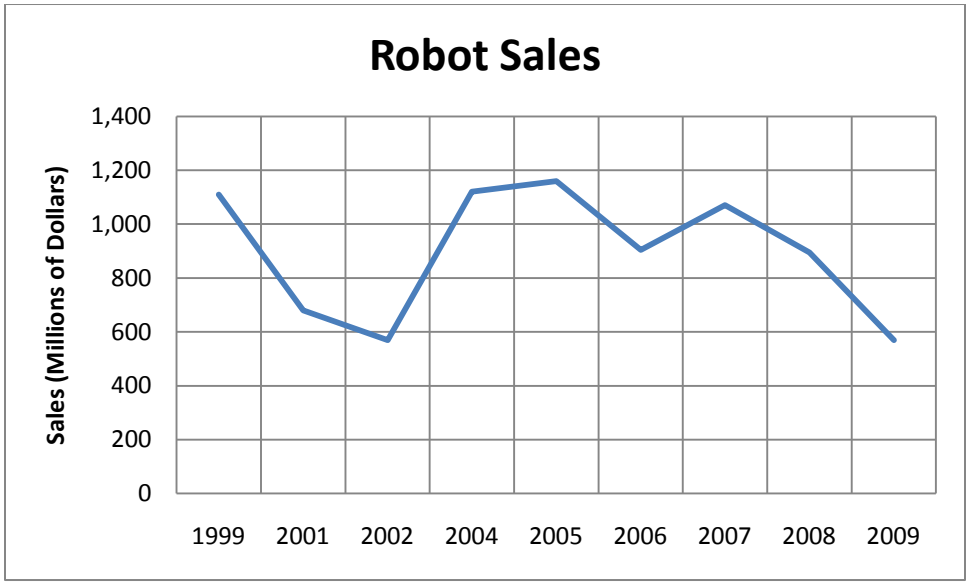

Figure 22 - Total sales of new robots in North America from 1999 to 2009.

Appendix D: Robotic Firms Currently Hiring

This list was compiled by querying RIA member institutions. It is current as of May 28, 2010.

	ABB Inc.	MI	United States	Supplier
	Applied Manufacturing Technologies	MI	United States	Supplier
	Applied Robotics Inc.	NY	United States	Supplier
	ATI Industrial Automation	NC	United States	Supplier
	Automation & Control Technologies, Ltd.	OH	United States	Supplier
	BAE Systems		United Kingdom	Integrator
	EPSON Robots	CA	United States	Supplier
	Lockheed Martin	MD	United States	integrator
	Flexicell, Inc.	VA	United States	Integrator
	Interlink Controls	TX	United States	Integrator
	IRobot	MA	United States	integrator
	Motion Controls Robotics, Inc.	OH	United States	Integrator
	Panasonic Factory Solutions Company	IL	United States	Supplier
	Progressive Machine & Design, LLC	NY	United States	Integrator
	Remtec Corporation	OH	United States	Supplier
	RobotWorx	OH	United States	Integrator
	Tennessee Rand Company	TN	United States	Integrator