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Teaching Mechatronics for New Business

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ABSTRACT

Mechatronics engineering is one of the most important knowledge that is creating new business around the world. The new electronics devices, medical sensing systems, or industrial intelligent process are few examples about how the integration of technology is getting new successful business in different sectors. The variety of point of views in the teaching process about mechatronics engineering enrich the human knowledge, and produce innovative ideas that can be used to create original solutions to improve products, processes and services.

Brief information about Mechatronics

The word Mechatronics was coined by the Japanese Ko Kikuchi of Yaskawa Electric Co. Chiyoda-ku, Tokyo in 1969. In that time, mechatronics was defined as a way to design electromechanical products to ensure optimum systems performance. In few years, Yaskawa Electric Co. adopts a commercial strategy based on innovation & technology. At the time, this strategy is the base of their successful economy.[1] No many people knows about mechatronics is, but every body knows about products developed with a mechatronics philosophy by a technology integration, since a small electronic watch to a sophisticated medical device. There are many definitions about mechatronics.

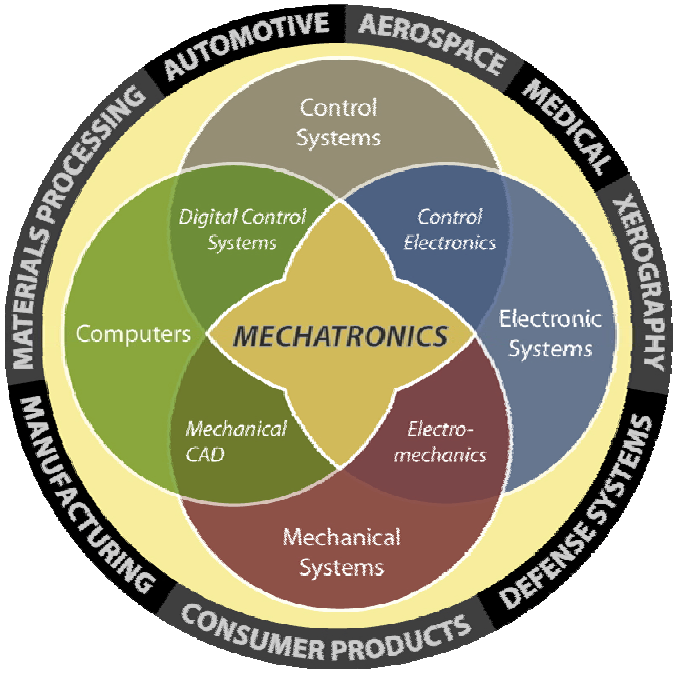

Figure 1. Aerial Venn diagram from Rensselaer Polytechnic Institute that describes the various fields that make up Mechatronics

[1] Mecha … what?, by Richard Comerford, IEEE Spectrum, August 1994, p.p. 46- 49.

One of the more accepted definitions is from Ph. D. Kevin C. Craig that says[2]: Mechatronics is the synergistic integration of physical systems, electronics, controls, and computers through the design process, from the very start of the design process, thus enabling complex decision making. Integration is the key element in mechatronics design as complexity has been transferred from the mechanical domain to the electronic and computer software domains.

Mechatronics is an evolutionary design development that demands horizontal integration among the various engineering disciplines as well as vertical integration between design and manufacturing. It is the best practice for synthesis by engineers driven by the needs of industry and human beings. Some actual definitions consider the mechatronics as the integration of mechanical engineering, electronics engineering, and information technology. [3]

Teaching Mechatronics in North America

In the last 20 years, several recognized Universities and Research Institutes in America had created different undergraduate academic programs about mechatronics as a way to get a high level education on technology.
The Institute of Electric and Electronics Engineers (IEEE), the biggest engineering association in the world, it is in charge to edit the Transaction on Mechatronics under the supervision of the Robotics and Automation Society. Universities as Colorado State, Ohio, Georgia Institute of Technology, University of Washington, Iowa University, Purdue University, Massachusetts Institute of Technology, and others, makes an important and constant effort to actualize the topics about robotics and mechatronics as an strategy to develop new technology methods, products and services [4]. There is a relevant interaction between universities, private companies, and government in different levels to develop and transfer technology to make new business. According with Reed Business Information, it is estimated that industrial controls, a part of mechatronics technology, create a $200 billion per year global market in two parts -- process management and factory automation controls [5]. By other hand, reported sales of motors, electronic drives, controllers, actuators and other motion control components are up by 3.7% from first quarter 2007, according to results of a recent report on the motion control industry, over a billion dollar global market. The findings also show reported shipments for the quarter grew steadily to $503 million. The report, produced by the Motion Control Association (MCA), includes sales volume, sales growth, geographic sales distribution and sales by product category figures for the global motion control market. [6]

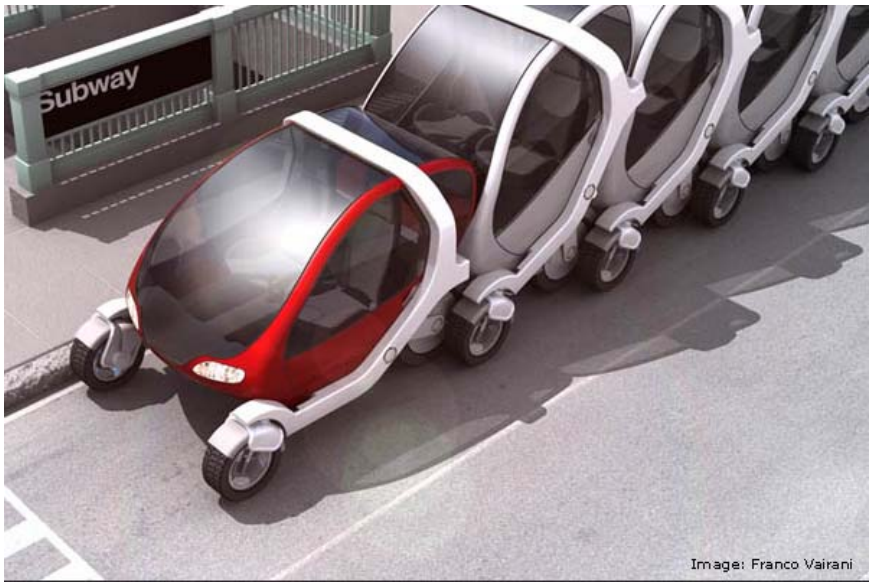

Figure 1.The “City Car” from Massachusetts Institute of Technology

[2] Marquette University, Ph. D. Kevin C. Craig , http://www.eng.mu.edu/~craigk/ (February, 2008)
[3] On the Design and Control of Mechatronics Systems – a survey, Iserman, R., IEEE transactions on Industrial Electronics, vol. 43, no.1, pp. 4-15.
[4] http://cities.media.mit.edu/projects/citycar.html , February 2008.
[5] Reed Business Information, http://www.controleng.com/article/CA6534704.html (February, 2008).
[6] Motion Control Association Announces Release of Second Quarter Industry Statistics, Jennifer Hayman, Robotic Industries Association, http://www.roboticsonline.com/public/articles/details.cfm?id=3175 (February, 2008)

Teaching Mechatronics in South America

The first academic program on mechatronics engineering was done by the Universidad Anáhuac México Sur in 1992. At the time, there are around 80 educative institutions that offer studies on mechatronics in Mexico. There are different points of views about the teaching engineering; most of them are oriented to prepare technicians with abilities to design and implement new innovative ideas for the improvement of industrial processes. The Mexican Society on Mechatronics was founded ten year ago, and it has contributed to promote what mechatronics is, and also to impulse the creation of other similar societies in South America, as the Peruvian and Chile Mechatronics Associations. There are academic programs about mechatronics engineering in Peru, Chile, Argentina, Colombia, Costa Rica, Brazil, Ecuador, and Cuba, mainly [7]. In general, The relationship between Universities and Industrial Companies is extremely poor. There are some successful projects about automation and robotics, but is required a better interaction to get social impact and benefits for the society. The Ibero-American Program for the Development, Science and Technology founded in 1984 with the participation of 19 countries in South America, Spain and Portugal, reports as international relationship between Governments is oriented for a scientific cooperation in Technology of Information and Communication as the bigger area, followed for the Technology for Industrial Production in 2001.[8]

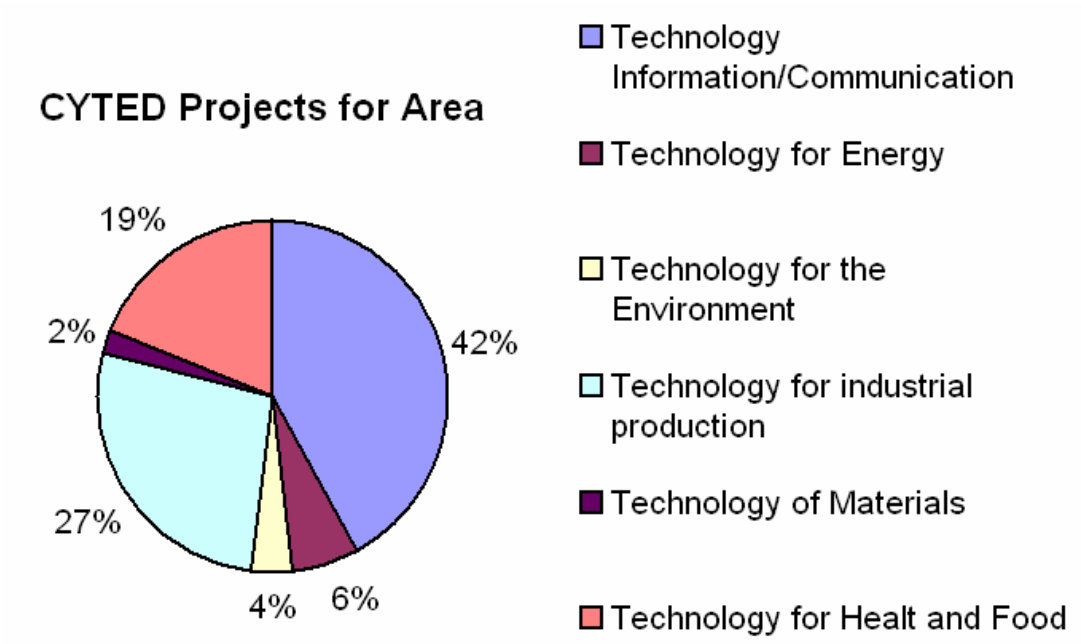

Figure 2.Research projects under the support of CYTED

Governments are analyzing how mechatronics engineering programs can offer good conditions for the development of their countries [9, 10].

[7] Noticias RIBAMEC, No. 1-10/2000, Laboratorio de Mecatrónica. Dr. Roberto Frias, Universidad do Porto, CITED.
[8] CYTED, Programa Iberoamericano de Ciencia y Tecnología, Reporte 2000-2001.
[9] Mexican Economy Minister. 3° Reunión de Seguimiento y evaluación del Estudio y Prospectiva de la Mecatrónica en México, Internal Report, Dirección General de Industrial Pesadas y Alta Tecnología, Febrero 2008.
[10] National Council for Science and Technology Develop, Annual Report. 2006. Brazilian Government.

Teaching Mechatronics in Europe

In Europe, there was no idea about mechatronics engineering 30 years ago. But now, the time is different. Since the mechatronics was considered by the main European Universities as a revolutionary way to design and improve new products, and create innovative ideas with high tech as a support, there is a clear objective to create benefits to the society, and business too. The Danish Mechatronics Association, The Mechatronics Group of Finland, The Hungarian Mechatronics Association, y several research institutes from Italy, New England, Germany and Sweden starts the teaching process about mechatronics engineering in the 90s. [11]

At the time, there is very intensive interaction between all European countries and private companies to develop with creative and original ideas new concepts of products that enrich the human lives. The European Center for Mechatronics [12], the Research and Development Center for Mechatronics [13], and the Institute of Industrial Technologies and Automation [14] are some examples of institutes with excellent international reputation to make original research based in Technology with a clear vision to put into the market the results of their projects. The main Schools and Faculties of engineering are teaching mechatronics on these days with the goal to get a quick impact to improve manufacture systems, medical devices and communication systems.

An Educative International Project named: Eumecha-pro, will strive towards a better educational framework that delivers excellent mechatronic engineers to the manufacturing industries. Mechatronics education requirements and approaches will be analyzed, resulting in a European vision on how education can be improved and be made more coherent across Europe . [15]In Europe, manufacturing activities represent an important part of the national economy and are still increasing. The global competition obliges to the companies to enhance the performance of the products and to develop and produce more complex components and sub-assemblies. This requires a lot of research and innovation in the field of product conception and production systems, where the mechatronics engineers do this specialized work with a fast tracking to make business. Companies in the sectors of the technology industry realize that the lion's share of their turnover is generated by exports. The most important markets are in Western Europe, followed by North America and Asia. [16] On these days, there are several important educative programs about mechatronics in all Europe, not only in postgraduate or graduate levels, but also in primary and secondary schools.

Figure3. Kids are playing with robots and learning mechatronics concepts.

[11] Memis A., Robert M. Parking, “Engineering Education for Mechatronics”, IEEE Transactions on Industrial, Electronics, Vol.43, No.1, February 1996.
[12] http://www.aps-mechatronik.de/ , February, 2008
[13] http://me.mecatronica.pub.ro/ , February, 2008
[14] http://www.itia.cnr.it/index.php , February, 2008
[15] European Mechatronics and Intelligent Manufacturing, Cris Decubber
[16] Agoria, http://www.agoria.be , The Federation for Technology Industry, February, 2008

Teaching Mechatronics in Asia

An obligatory reference about what is going about mechatronics in Asia is Japan. This country is considered the leader in this area for the relevant impact in the world with the Japanese electronics devices. Mechatronics is fast becoming an important component of modern products and processes and is poised to become a key technology to employ to gain a competitive edge in the modern manufacturing era wherein products and processes are becoming highly integrated in functionalities. The development of mechatronics will therefore be crucial to the continued competitiveness of a manufacturing intensive economy, typical of many countries in Asia. [17] In Japan, the government has an important influence to define the research areas where robotics and mechatronics get relevant social impacts, like: medicine, human communication, human rescue, or entertainment.[18]. Japanese government had approved several laws to stimulate cooperation between universities and industry, as well to help nurture small businesses. MITI for example, started to give grants to small companies under a program called "Foundation for Venture Business." Similar programs are going on in China, Russia, Taiwan, Korea, Hong Kong, Iran and Israel. Mechatronics is used extensively in robotics, aircraft and other systems that require intelligent mechanical elements. For example, Russia's traditional strengths in aerospace, defense and specialist machinery are increasingly exploiting mechatronics design approaches, combining mechanical devices with electronics and software control systems. A recent DTI Global Watch Mission to Moscow and St Petersburg explored some of the latest developments [19]. There are academic programs oriented for the improvement of the grounding level of scientific and educational personnel for mechatroonics, an involvement of talented young people into participation in advanced scientific researches on the priority directions of science and technology development "Industry of nano- systems and materials", "Information-and-telecommunication systems", and increasing of science and education level due to cooperation and increasing of young scientists mobility in the region.

Figure 4. Mechatronics applied in manufacturing

[17] Mechatronics , Various Developments in Mechatronics in Asia , TAN K. K., LEE T. H. , DOU H. F. ,LIM S. Y. , ISSN 0957-4158 , Elsevier Science, Oxford, ROYAUME-UNI (1991)1998, vol. 8, n°7, pp. 777-791

[18] Japanese Government Research Programs, http://www.wtec.org/loyola/mechtron/01_06.htm

[19] Proc. of the Int. Scientific-and-Technological Exhibition-Congress, "MECHATRONICS AND ROBOTICS (M&R-2007)", Mechatronics in Russia: The Story so far November 2006, Philip Moore, Mechatronics Research Group, De Montfort University, 2007

Teaching Mechatronics in Africa

In Africa there are important Universities that teach engineering programs. The University of Cape Town (UCT) in South Africa defines mechatronics as an interdisciplinary branch of engineering which combines a fundamental study in mechanical engineering with light-current electrical engineering. Mechatronics student at UCT will gain a foundation of understanding in physical science, advanced engineering mathematics, electro-mechanical control theory, microcomputer technology, systematic engineering design and some principles of engineering management. In addition, the mechatronics program offers final-year optional courses in related fields, such as bio-medical engineering, power electronics and machines and industrial management. The Mechatronics engineer in industry may require expertise across a broad range of engineering disciplines, and will be especially well-suited to a career in light manufacturing or process control. Mechatronics engineers may become involved in fields such as instrumentation, automation, robotics, bio-medical engineering or machine vision [20]. For the Tswane University of Technology in Western Cape, South Africa mechatronics describes the integration of electronic engineering, electrical engineering, computer technology and control engineering, with mechanical engineering. This process forms a crucial part of design, manufacture and maintenance of a wide range of engineering products and processes. A consequence is thus the need for engineers and technicians to adopt an interdisciplinary and integrated approach – skills and knowledge that are not confined to a single subject area. They should operate and communicate across a range of engineering disciplines [21]. By other point of view, the mechatronics engineering program from the Nelson Mandela Metropolitan University is relevant because mechatronics engineers play a key role in the design, development, manufacture and operation of a variety of products – from video players and automatic cameras, to robots and fully automated plants for manufacturing, packaging, and the process industries, to highlight a few. It is a new focus area that promises to become even more important in the future [22]. The recognized University of Johannesburg includes engineering mechatronics studies in their academic programs. Department of Mechanical Engineering Science is in charge of the mechatronics engineering program. The Department has excellent and dedicated teaching staff, many of whom are actively involved in advanced research. Four research groups are active in the Department, and recent research output includes the publication of a range of journal papers, books, chapters, research reports and conference papers. The Department is home to fully-equipped, modern laboratories and equipment, while strong links exist between the Department and industry and professional associations. Focus study areas include aeronautics, manufacturing and mechatronics. Programs offered by the Department are accredited by the Engineering Council of South Africa (ECSA) [23]. Mechatronics Engineering in University of Stellenbosch is under the concept with automation as the current key to productivity, the need for mechatronics (which makes it possible to generate simpler, more economical, reliable and versatile systems) increases by the day. Mechatronics engineering is a synergistic combination of precision mechanical engineering, electronics and computer systems. A typical mechatronics system is characterized by close integration of the mechanical components, electronic sensors, mechanical and electrical actuators and computer controllers. Mechatronics engineering is an interdisciplinary engineering field that serves the purpose of controlling advanced hybrid systems. These systems are found in numerous industry sectors where mechanical and electronic engineering are interfaced with computer systems, such as aerospace, automotive, chemical processing, computers, communications, electronics, healthcare, manufacturing, and mining [24].

[20] http://www.uct.ac.za/faculties/ebe/degrees/undergraduate/ , February 2008.
[21] http://www.tut.ac.za/default.aspx , February 2008.
[22] http://www.tut.ac.za/default.aspx , March 2008.
[23] http://www.uj.ac.za/mechsci/ , March 2008.
[24] http://www.sun.ac.za/ , March 2008.

Teaching Mechatronics in Oceania

The School of Mechatronics Engineering from the University of Western Sydney is the first school in Australia as start to teach mechatronics few years ago. The engineering academic program was established with the goal to respond the industrial expansion of the Western Sydney region with highly-skilled human resource [25]. The main objective of mechatronics engineering courses is to educate engineers capable of successfully applying mechanical, electronics, and software technologies leading to the design and manufacture of intelligent machines. The Monash University in Sidney have a Bachelor of Mechatronics Engineering for 2008**.** Mechatronics engineers are in great demand in teams designing new mechatronics products or upgrading existing devices by adding mechatronics elements to improve their performance. Mechatronics engineers are highly skilled professionals, involved in the design, construction and running of factory production lines and processes. Their skills in microcontrollers, programmable logic controllers, industrial sensors, hydraulic, pneumatic and electric drives, are highly sought after in the design of intelligent products. Mechatronics is at the cutting edge in the development of new devices, research opportunities exist in nanotechnology, robotics, bioengineering and other related industries. Opportunities for mechatronics engineers are virtually unlimited; graduates from this program are in high demand, particularly in South East Asia [26]. Te University of Canterbury in New Zealand is teaching a mechatronics undergraduate program. A mechatronics engineer is defined how a person that develops a systems approach to design and development and is able to combine mechanical design with electrical and computer design to produce new smart products.

How is the leadership about teaching mechatronics?

The modern tendencies in engineering education are oriented not only to form people with excellent skill to solve engineering problems by multicultural team work, or abilities to plan engineering projects with leadership. The tendencies show an education with a point of view in new business derivate from the research work. New engineers are needed with integral vision for the technological changes on these days. There are few Universities in the world that define this leadership, because the different real needs in their countries are getting support from other different disciplines. It is know that successful companies, as same as Universities, makes prospective studies to define the lines of work for next years, in order to get a better position in the global market. For more than one decade, Tsukuba University makes plans to create new research groups on robotics and mechatronics with the ambition to found new companies made by professors and students. One example of this plan is HAL-5. A robot suit developed by Professor Sankai of Tsukuba University / CYBERDYNE Inc. to enhance and amplify physical functions. Changes in bioelectric potential that occur when a person attempts to move a muscle are detected by sensors to initiate motor control. The design is intended to achieve a pliant, flexible form and maximum safety while at the same time maintaining the functionality necessary from a medical standpoint. Thought was also given to entertainment aspects in terms of gaining deeper recognition of HAL by society [27].

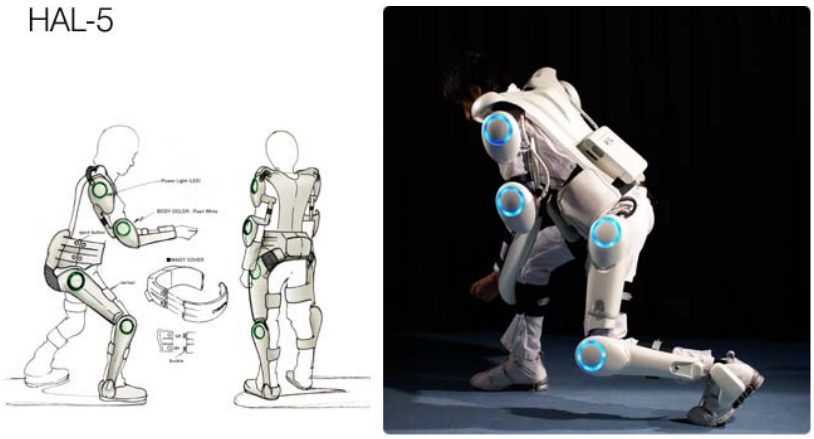

Figure 5. The Hal-5 developed in Tsukuba University by Prof. Sankai.

[25] A submission to the higher education review committee, School of Mechatronics Engineering, University of Western Sydney, J. Gal, G. Fang, V. Ilic, B. Roberts, and J. Vincent , Department of Education, Employment and Workplace Relations, May, 1997.
[26] Monash University, http://www.monash.edu.au/study/coursefinder/course/3280/ , February, 2008.
[27] http://www.elm-design.com/english/design/hal-5.html , March, 2008

With the same idea to create new products with mechatronics philosophy, The RoboScooter is a recent developed vehicle. This vehicle is a lightweight, folding, electric motor scooter. It is designed to provide convenient, inexpensive mobility in urban areas while radically reducing the negative effects of extensive vehicle use – road congestion, excessive consumption of space for parking, traffic noise, air pollution, carbon emissions that exacerbate global warming, and energy use. It is clean, green, silent and compact. The unique design of the RoboScooter is the outcome of a collaboration involving SYM (Sanyang Motors), ITRI (Taiwan's Industrial Technology Research Institute), and the Smart Cities group of the MIT Media Laboratory, led by Professor William J. Mitchell. The final show-quality prototype was presented at the Milan Motor show on November 6-9th, 2007 [28] .

Figure 6. The Robo Scooter developed in MIT.

To enrich products and service with innovative concepts, numerous companies in the biotechnology, pharmaceutical and medical technology sectors have already opted for create high tech offices to high tech companies. One example is the florid tower, most notably US pharmaceutical giant Pfizer. Pfizer alone has rented several thousand square meters, due to the outstanding technical quality and high security standards, and regularly holds its company meetings in the penthouse Circle Lounge, which provides both a spectacular view and stylish atmosphere. Other smaller companies and the Central European sales offices of international players have also decided to locate to the florid tower. For example, pharmaceutical companies Serono and Phadia, as well as medical technology firm Straumann, operate from the left bank of the Danube. The state-of-the-art office facilities in the florid tower meet the highest international office standards. Chilled beam ceilings and a climate façade with exterior sun protection provide a pleasant work environment, and the Windows can be opened, providing oxygen for those doing the brain work. The flexible layouts make it possible to partition the room in every conceivable manner, from open space offices to small think-tanks for concentrated work [29]. New businesses are emerging with technology support as an attractive strategy to get successful products in the global market. The chance to innovate original ideas will be the knowledge revolutions for the next years, and companies with a clear strategy to get advance of these conditions have enormous potential for the future.

[28] http://cities.media.mit.edu/projects/scooter.html
[29] Location Austria. Magazine Bio & High Tech, 04/2006.