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The History of the Creation of Engineering Careers in México and its Relationship with Social Innovation

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Abstract - There is an intuitive relationship between the creation of engineering careers and the social innovation in any country. In the global scenery a nation's economy is the main driver of its social innovation. As in all countries, engineering careers in Mexico have always been closely related to the economic activity through the assimilation, operation and maintenance of the technological platforms used by the nation's public and private organizations to perform their operations. Technological change has been a major factor influencing engineering education in last decade provoking that Mexican engineers needed to expand their actuation areas to attend more than just the industry's operative needs. Today Mexican engineers are also involved in research and development innovation projects. Through an investigation of the history of the creation and evolution of the engineering careers based in the available data of the Facultad de Ingenieria (FI) de la Universidad Nacional Autonoma de Mexico (UNAM), in this paper we intend to show that in the country engineering careers and professionals always have had a relevant actuation in its development and have been behind the economic and social innovation processes.

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I. Introduction: Engineering Careers, Fostering Social Innovation

Vandervert [25] noted that innovation has to be with the production of new useful ideas and products and it is normally associated to projects that are the media where individuals creativity and talent be transformed into the ideas and or products that people wish to use, contributing to solve important society problems; this phenomena is called firm innovation. Technology is created in innovation projects and is embodied as tools, products, processes, methods, systems and procedures for specific purposes. Bas, et., al. [1].

Economic innovation is typically associated with the creation of wealth for individuals, companies and nations. Khalil & Ezzat, [12].

For Sternberg, et al., [23], cited by Vandervert (op. cit., pp. 1103) aggregated innovation effects convert in a *social force* driving different knowledge fields. As Major & Cordey Hayes [14] indicate, innovation is characterized for the production of *flows* and combinations of knowledge and information. In summary the main product of innovation projects is knowledge in many types. Organizations must develop an appropriation capacity for the knowledge developed in the economic innovation processes in order to finally produce commercial benefits. Teece [24]; Moser, [18].

In the whole complex society the macroeconomic phenomena described produces gradually changes improving people's living standards and provoking Society *innovation* as the final main result of the process.

Many different professionals, organizations and individuals participate in the economic & society innovation processes. Reducing the complexity of the phenomena, Figure 1 intends to show what are the engineering actuation areas within the continuous processes described. As in all the world, in third world counties the basic activities of engineering individuals are related to the operation & maintenance of industrial plants, systems and devices. Nowadays engineers also participate in research, technology and new product development projects producing new products, promoting enterprise competitiveness and generating an important economic spill out. Engineers normally work within public and private firms and organizations; although, in Latin-American countries, and particularly in Mexico, only big firms have their own capacities to perform innovation projects. To overcome this problem there are research and development public government financed institutions that can help micro and small enterprises with their R&D requirements.

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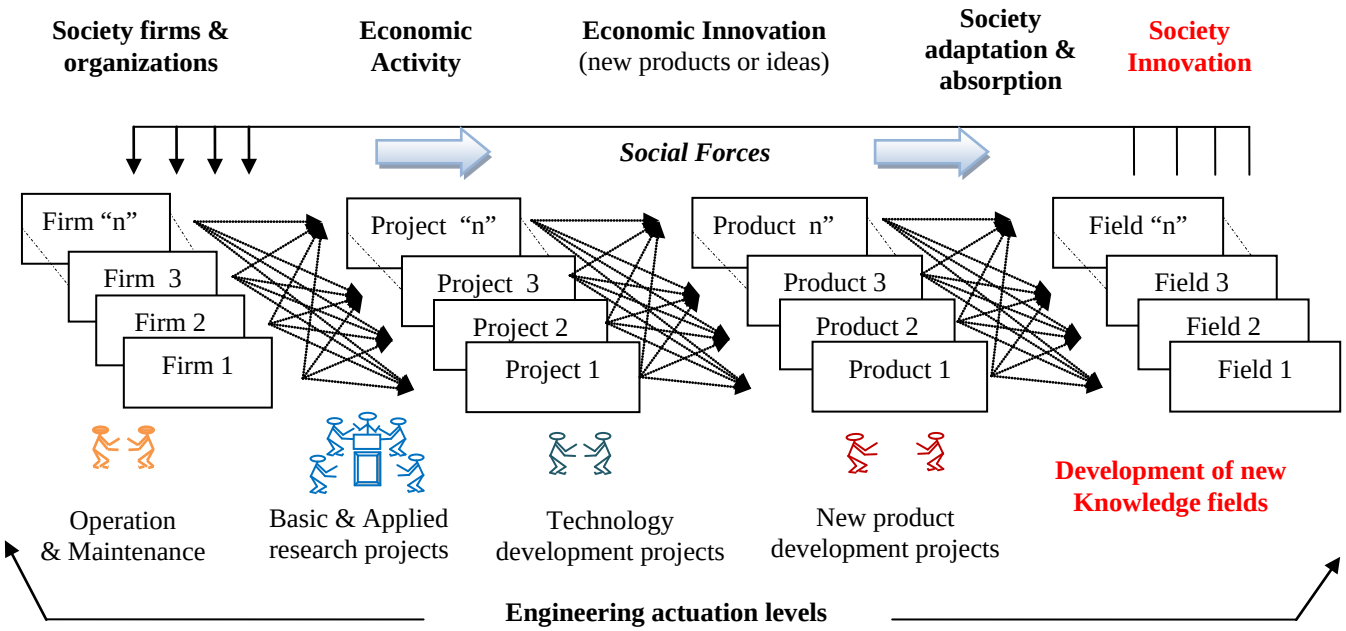

Figure 1 : Engineering actuation level for Economic & Society Innovation

In the next section we will review the historical creation and the evolution of the engineering careers in Mexico in the context of the technological platforms available and related to the economic and social innovation processes.

II. Engineering Careers Evolution In Mexico (<1500 To 2000 AC)

As in other countries, Mexican engineers schools and faculties have been immersed in the response of the education's societal system to the basic population problems. In Figure 2 it can be seen that during the main part of the Spanish Colony years (1500-1800 AC), construction engineering professionals were in charge of constructions for living, water handling and food, merchandize and people transportation. The main economic activities were the mining exploitation, the agriculture, the livestock and the commerce; the first formal engineering career in Mexico was *Mines* created in 1792 at the Hospicio de San Nicolas Hidalgo in Michoacan.

By the end of eighteen century (1800-1850 AC), basic industrial chemical processes for breweries, beverages, food, pharmacy, paper production, steel, cooper, tanneries, rubber and heavy machinery sawmills appeared. The first steam electric power plants were installed and the first refineries began to work.

During all XIX century the engineer careers available to respond to those active industrial sectors were: *construction*, *mining*, *geologist*, *topography*, *textile* and chemical engineering. Figure 3

The Universidad Nacional was created in 1910 including the Engineers National School. In 1915 the *hydraulic and construction* career and the *mechanical & electrical* engineer practical school were created. Díaz & Saldaña [6].

The Escuela Nacional de Química Industrial (ENQI) was founded in 1916 and incorporated to the Universidad Nacional Autonoma de Mexico (UNAM).

The career of *chemical engineer* was created in 1925. Later on, in 1938 the *oil engineering career* was created to attend oil refineries and petrochemical plants. The *geologist* career was created about 1940 to back up the intensive oil exploration works developed by the oil industry.

To address the waste disposal needs of the new industries and the growing cities, the *municipal* and *sanitary engineering careers* were created contemporarily to design and develop the sewage system required for the cities and the industrial waste water treatment plants.

In 1929 the Universidad Nacional got converted in the Universidad Nacional Autónoma de México (UNAM) and the Escuela Nacional de Ingenieros was transformed in the Facultad de Ingeniería de la UNAM (FI-UNAM) having the primary objectives of maintaining the existing careers and to create the new ones required in order to respond to the country's intense ongoing industrialization process.

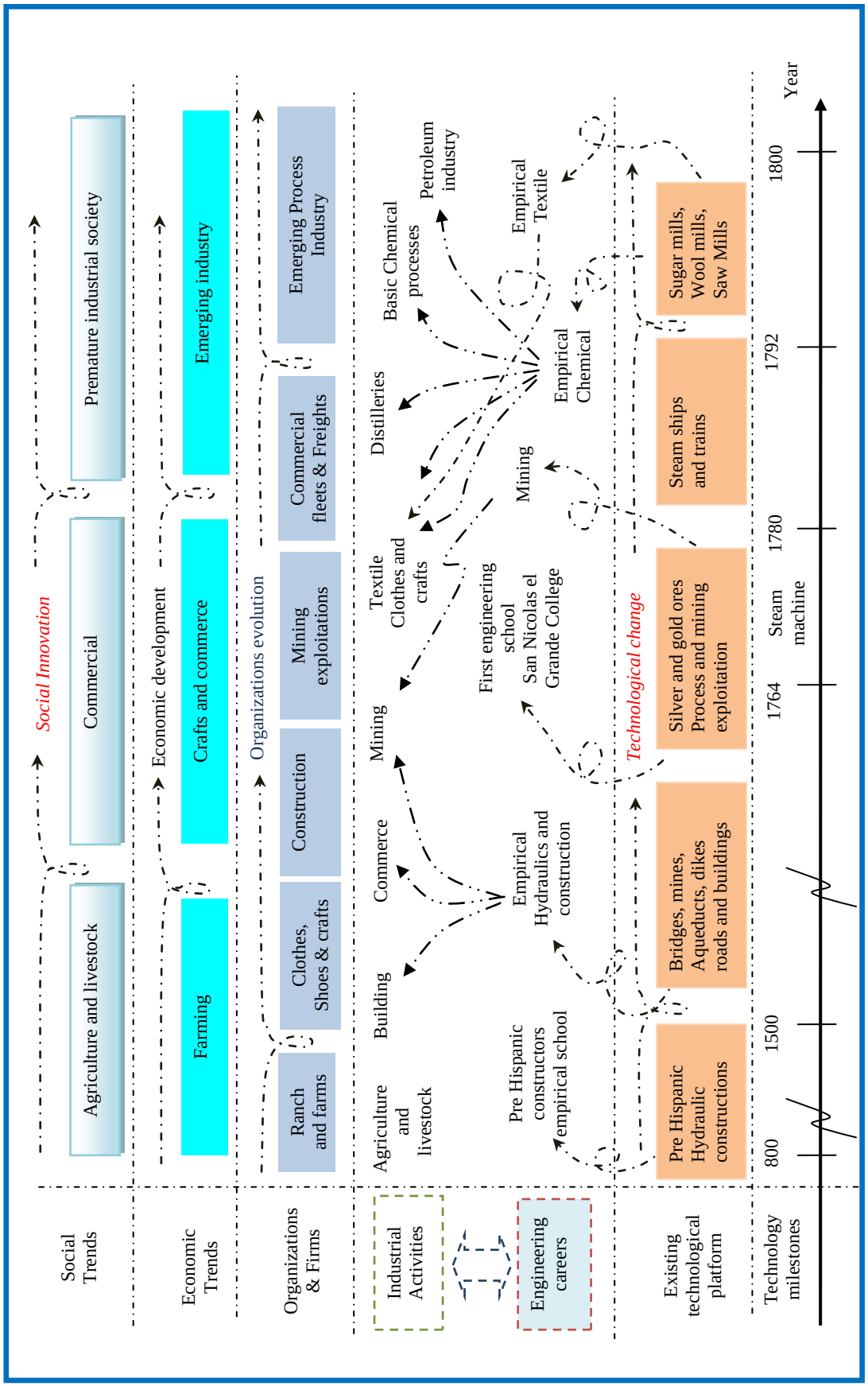

Figure 2 : Engineering careers, technological platform and social innovation (1500-1800 AC)

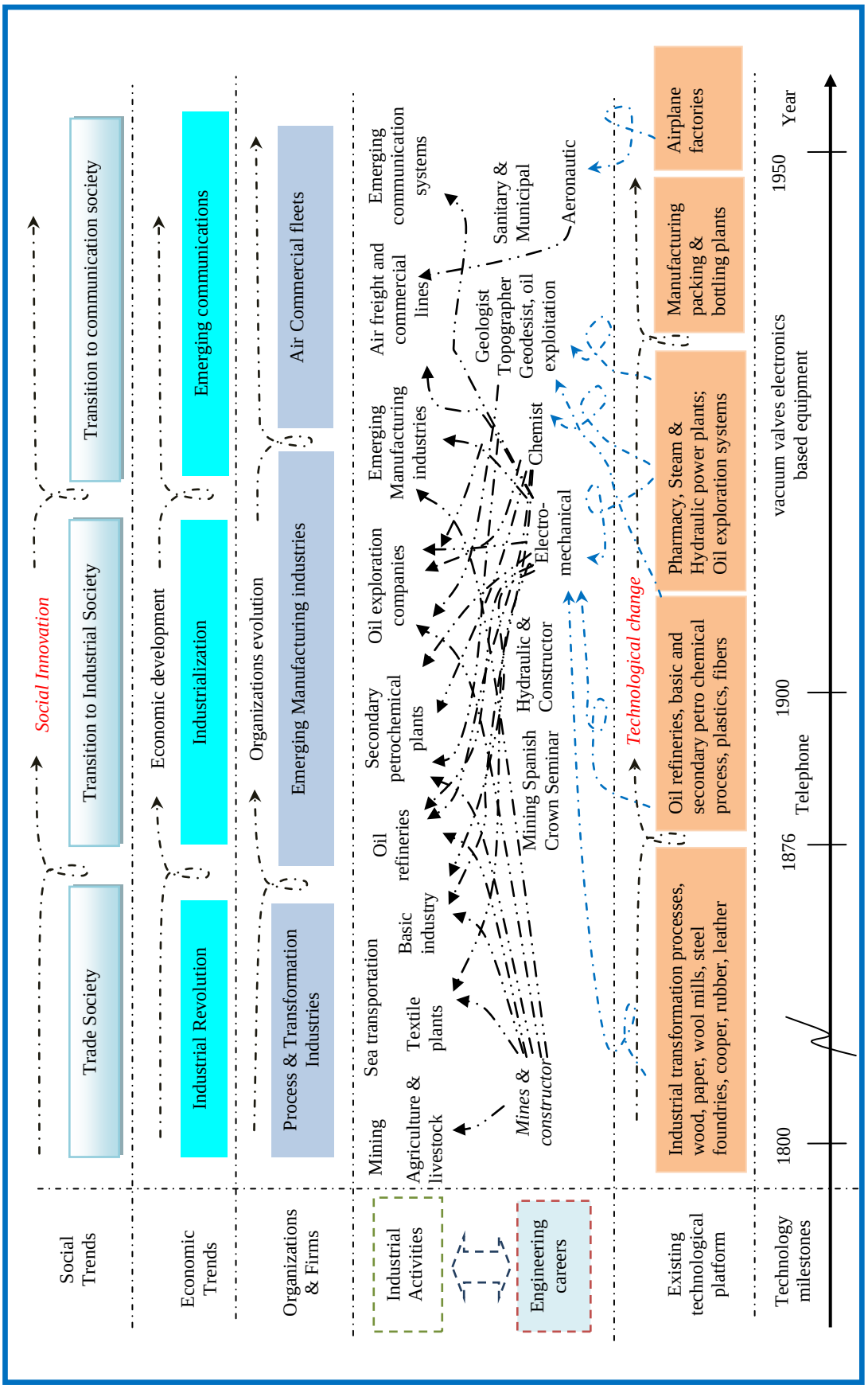

Figure 3 : Engineering careers, technological platform and social innovation (1800-1950 AC)

By 1950 the engineering careers offered by the FI-UNAM were: *construction, geology, electromechanical, topography, geodesist, petroleum exploitation, mines and metallurgy, sanitary and municipal and aeronautical*. The scope of the *electromechanical* career included the emerging technologies of the communications industries such as telegraphy, telephone, radio broadcasting and television.

The intense use of mainframe computers in the middle of the seventies determined the creation of the *computation engineer* career in 1981. The *geophysics* career was also created in 1981.

Internet technology was available at the end of the twentieth century giving origin to the globalization phenomena. The *electromechanical engineering* career got transformed in the *mechanical*, *electrical*, *electronic*, and *industrial* engineering careers responding to the intense technological change. Drucker [7].

III. Engineering Careers And Technological Change (2000-2030 AC)

According with Saito [20], the technological convergence of the computer and communications systems come out with the commercial availability of the global satellite communication broadband networks and the Internet technologies transforming the world in a global village. Mc. Luhan, [17]. The globalization phenomena changed the way world economies design, produce, distribute and make the consumption of goods and services. Widdig & Lohmann, [26].

It was difficult for the firms to be converted in global organizations, Landry [13], but convergence permitted to the society members to have easier and transparent access to health, education, commerce and government services overcoming bureaucratic and geographic barriers. Chareonwongsak, [4].

Communication devices and technologies including satellite communication systems suffered intense number of innovations during the end of last century. Cellular phone systems emerged with the dissemination of fiber optics and satellite networks all over the world impacting world economics and all aspects of modern life, including entertainment. Pretty soon a new Internet version appeared including new technologies for data processing including audio, video, and images. Economic analysts consider this phenomenon as a new technological revolution, the TIC Revolution. The world main influencing technologies were the computers and communications (TIC).

A special technological field supported by the availability of the high velocity satellite networks, the fastest memories and powerful processors has been the telemedicine. Since the nineties it has been a continuous development of complex medical diagnostics systems based in medical imaging. Today the public health systems work in base to huge standardized data bases. The telesurgery will be a common procedure in the very near future. *Biomedical engineering career* was created to attend those fields in conjunction with the electrical and electronics engineers.

The industrial society got transformed into the new information society, Geisler, [10]; Sanchez, [21]. The professional people required to back up the new industries needed to have knowledge in electronics, computers and telecommunication fields. Responding to this phenomenon, the *telecommunications engineering* career was created in 1994. See Figure 4.

During last decade's intense global research and development has been carried in different areas, some examples are: new materials, micro electromechanical systems (MEM), and nanotechnology. It is expected in the very near future the commercial availability of the biological chips. World is in the way for the absolute convergence; next step will be the bio-convergence.

One of the R&D fields with an extraordinary growth is the biotechnology, particularly in the case of the investigations behind the food and bio pharmaceutical drugs. The biotechnology term refers to the methods and techniques used to produce substances from raw materials using living organisms. Sasson, [22].

It is expected that the continuous evolution of the capacities of the computational systems, will promote the evolution of the genetics R&D to produce human organs in lab which will be available in market ready to be transplanted some time ahead. The future petacomputers will be capable to perform a thousand trillion of floating point operations and eventually could be used in many auxiliary processes in order to modify the human's evolution. The petacomputer networks could eventually reach an intelligence superior to the one of the human being. Martin, [15].

The development of the emerging research fields is based in the intense interaction of the existing scientific knowledge and it depends in the last generation technological devices required for doing the research. Techno-science is the new field that recognizes the synergy and interdependence of research and technology and it is frequently associated with complex systems studies.

Many medium and big size manufacturing firms and chemical transformation process industries evolved in Mexico during the second half of last century. They always look forward for finding safely ways to increase productivity better quality standards using clean technologies and auto sustainable production systems. Figure 4

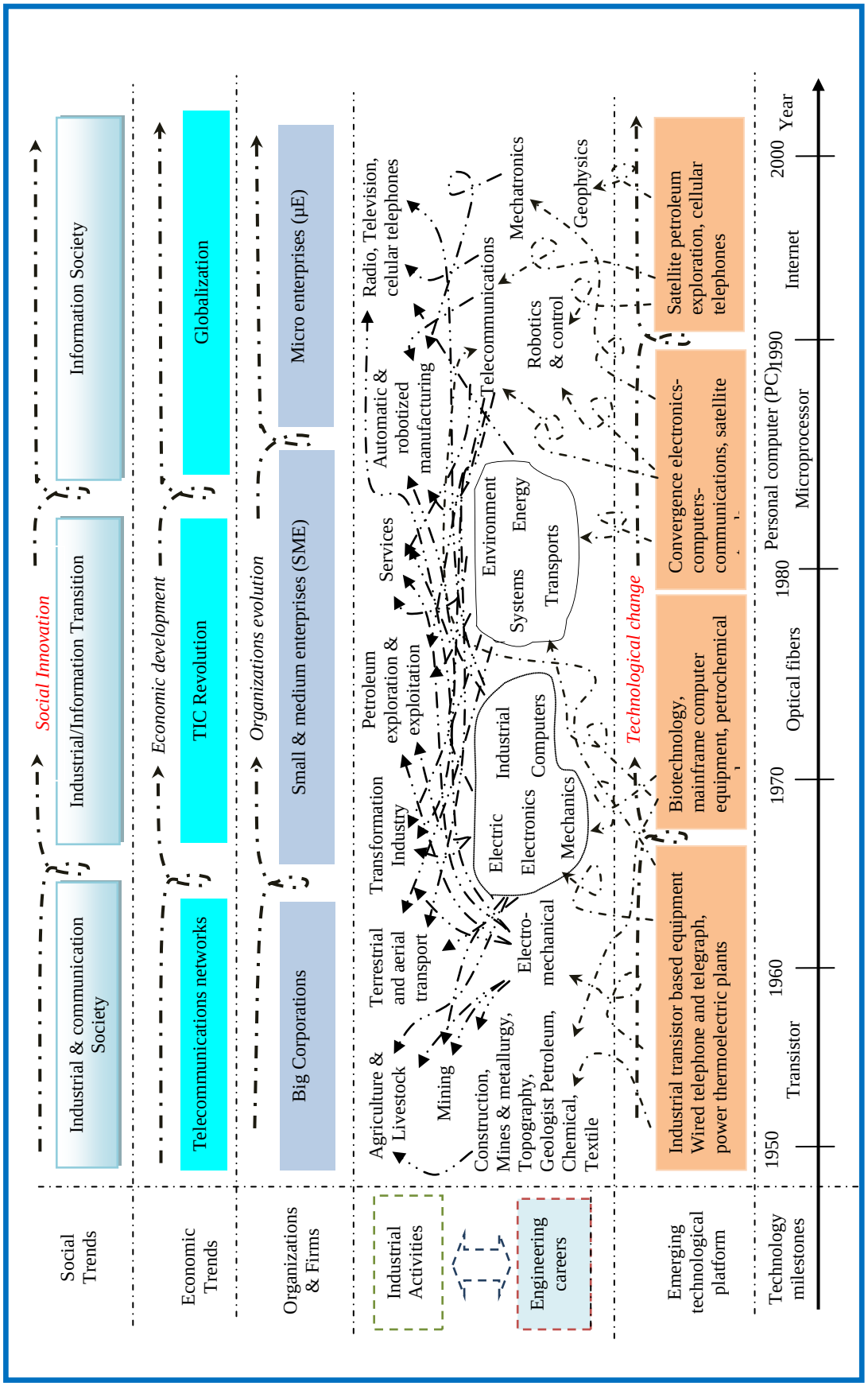

Figure 4 : Engineering careers, technological platform and social innovation (1950-2000 AC)

IV. The Last Thirty Years Economic Transformations & New Careers For Next Decades

Driven by the intense technological change and in order to be profitable, around the last quarter of the last century, enterprises diminished their size producing the gradual transformation of the big corporative firms in to small and micro enterprises (SME's). Today it is estimated that the SME's conform about 97% of the country economic units in Mexico, and are responsible of the generation of more than 50% of the Gross National Product. Diario Oficial de la Federación, [5].

In the new age the consumer required tailored products according to their own specifications. Competitors passed from being national to international and increased in number. In front of this situation, the enterprise learned to be flexible and to be tuned for new product manufacturing, understanding the importance of product diversification.

In a high turbulent environment with new consuming standards, continuously increasing technological change and global markets with growing number of regulations and competitors, enterprises needed to move fast in order to learn how to develop innovating products adapted to the new highly competed business environment. Bessant, [2].

High volume serial production systems became over passed, the new business scheme required adaptable production systems. The firm had to be capable to be organized in short time to produce the small quantity goods included in a purchase order.

To compete and survive in the new global market the SME's required to be highly specialized in some knowledge fields, identifying their core competences and learning to innovate promoting a new innovation culture. Foster, [9]; Campbell & Sommers, [3]; Zien & Buckler, [27].

The new market required complex products and in order to be successful SME's needed to establish strategic alliances with the big firms instead of competing with them. To get the production parts required from any place in the world the use of global services was essential. Eraydin & Armatli, [8].

The feasibility of the new global production scheme depended on the innovation networks. Internet was the technological tool responsible of their development. Rothwell [19]; Hinterhuber & Levin, [11]. Virtual enterprises appeared with the capability of changing its size integrating the number of people required according with the project to be performed, case to case.

In this environment, to increase quality, and to lower production costs new technological tools were required. Computer aided design (CAD) and computer aided manufacturing (CAM) systems were available in the market. In a short time they were used by SME's and virtual engineering and manufacturing firms for their innovation projects. To succeed firms required to be flexible and capable to learn and develop new knowledge based products. The phenomenon occurred globally fostering the emergence of the knowledge economy in which the knowledge was recognized as the main production factor. In that regard the *mechatronics engineering* career, was created in 2004 to prepare the professionals required to attend the automated and manufacturing robotic systems production industrial requirements.

Technological change dynamic processes have been increasing in this century. Everything indicates that tendencies will continue and therefore innovation will be favored by the new technology developed along.

Testing the society absorption capacity, hundreds of new scientific and technological knowledge based products will be launched to market. Trying to respond to this phenomenon in 2007 the UNAM created the *technology engineering career* to produce the professionals required to support this apparently never ending process.

In the near future biological systems possibly will be the biggest growing knowledge field launching to market hundreds of new high value products transforming the world industry configuration giving birth to a new economic system: the bioeconomy. Mc. Kelvey [16], therefore we expect the development of the *bioengineering career* by the end of this decade or the beginning of the next. The convergent knowledge domains probably be biological and biotechnological processes along with electronic, computers, telecommunication system and nanotechnology.

V. Conclusions

As we have seen, during the last 200 years engineering professionals in Mexico have been acting between the existing technological platforms and the firms pushing economy development and producing social innovation through the knowledge development.

Engineering professionals actuation working in the different organizations of the different economic sectors produced a *social force* capable to drive different knowledge fields while producing knowledge embodied in many different products and physical artifacts through the *flows* and combinations of knowledge and information.

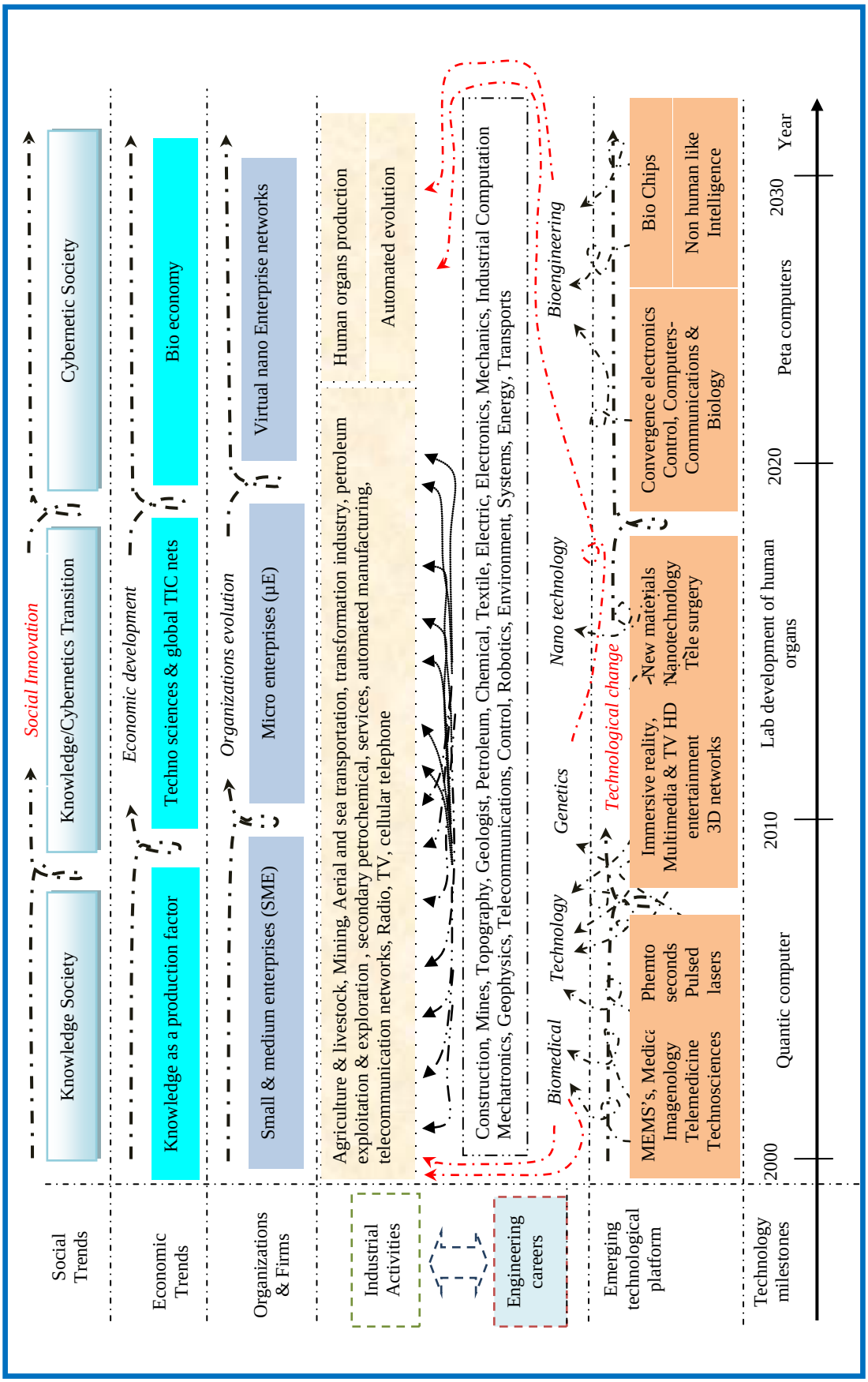

Figure 5 : Engineering careers, technological platform and social innovation (2000-2030 AC expected)

Engineers have not only backed-up enterprises and productive organizations for operating and maintaining their own technological platforms but also participate in research and development projects and working in teams with other professionals to develop an internal capacity to receive, adapt, absorb and use the big amounts of knowledge generated in and outside house.

The creativity, talents and abilities of the engineers dispersed in all the firms and organizations of the country have fostered knowledge development in the society improving indirectly the quality of life of the people and therefore pushing the society to innovate for being adapted to the technological global scenery.

Undoubtedly Mexican engineering have been a fundamental axis for the country's industrial development and for the well being of the integral society.

We envision that the dynamics of the techno-science fields will increase dramatically in next decades fostering the societal education system to find the way engineering careers form professionals capable to respond to both social needs and to the increasingly complex technological demands driving a permanent positive social change.

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