Turning Points in Construction

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Abstract

Socio-technical changes lead to new opportunities. Robots are customizing the industrialized mass production of non/manufacturing industries. Robots ameliorate adverse working and offer better living conditions during demographic changes in societies. Ultimately autonomous systems and robotics could reduce ecological footprint during extreme environmental conditions.

Keywords: automation, autonomy, industrialization, infra free, robotics, socio technical systems

1959: The turning point in industrialization 50 years ago?

The turning point in industrialization was triggered by the introduction of universal automation by industrial robotics. As a prerequisite George Devol patents a playback device for controlling machines, using magnetic recording in 1946. George Devol and Joseph Engelberger design the first programmable robot "arm" and use the term Universal Automation for the first time and later form the world's first robot company. It is called Unimation, Inc. (Universal Automation). Joseph Engelberger and George Devol's robot evolves into the Unimate in 1959. The Unimate robot combines industrial manipulator technology and nascent computer control technology. Unimation Inc. was the first company to make and sell robots to General Motors and General Electric for pick and place operations..

When I met Joseph Engelberger during ISR on 30, November 2005 we discussed the potential of construction robotics. After having listened to my presentation on construction robots he told me that " I can't describe a construction robot, but I know one when I see one". Deploying robotics in construction would enable to customize industrialized construction.

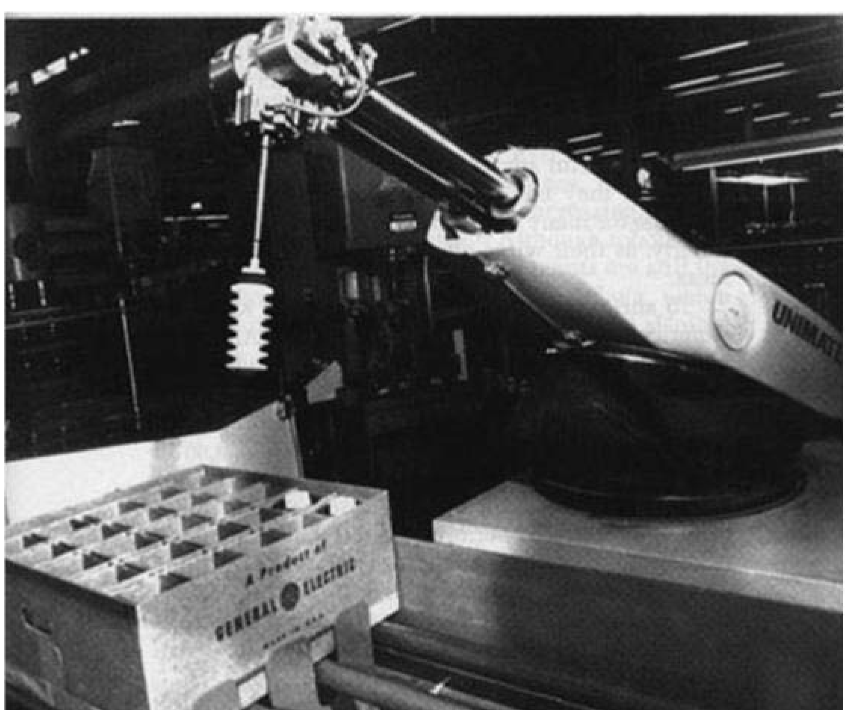

Fig. 01 Unimate robot (copyright J. Engelberger)

1959: The turning point in construction 50 years ago?

Konrad Wachsmann apprenticed as a cabinetmaker and studied at the arts-and-crafts schools of Berlin and Dresden and at the Berlin Academy of Arts. During the late 1920s he was chief architect for Christoph and Unmack, a manufacturer of timber buildings in Niesky. Wachsmann immigrated to the United States in 1941 and went into partnership with the architect Walter Gropius until 1948, an association that resulted in the formation of General Panel Corporation, which produced prefabricated building components.

The philosophy of General Panel System was the same as industrially produced systems such as General Electric, General Motors and JEEP (which originates from GEneral Purpose vehicle). In 1950 he was appointed professor at the Institute of Design of Illinois Institute of Technology, Chicago, and director of the department of advanced building research. His famous written works is The Turning Point of Building (1959; Eng. trans. 1961). In 1964 he joined the USC in L.A. as director of the Building Research Division and chairman of the graduate school of the department of architecture.

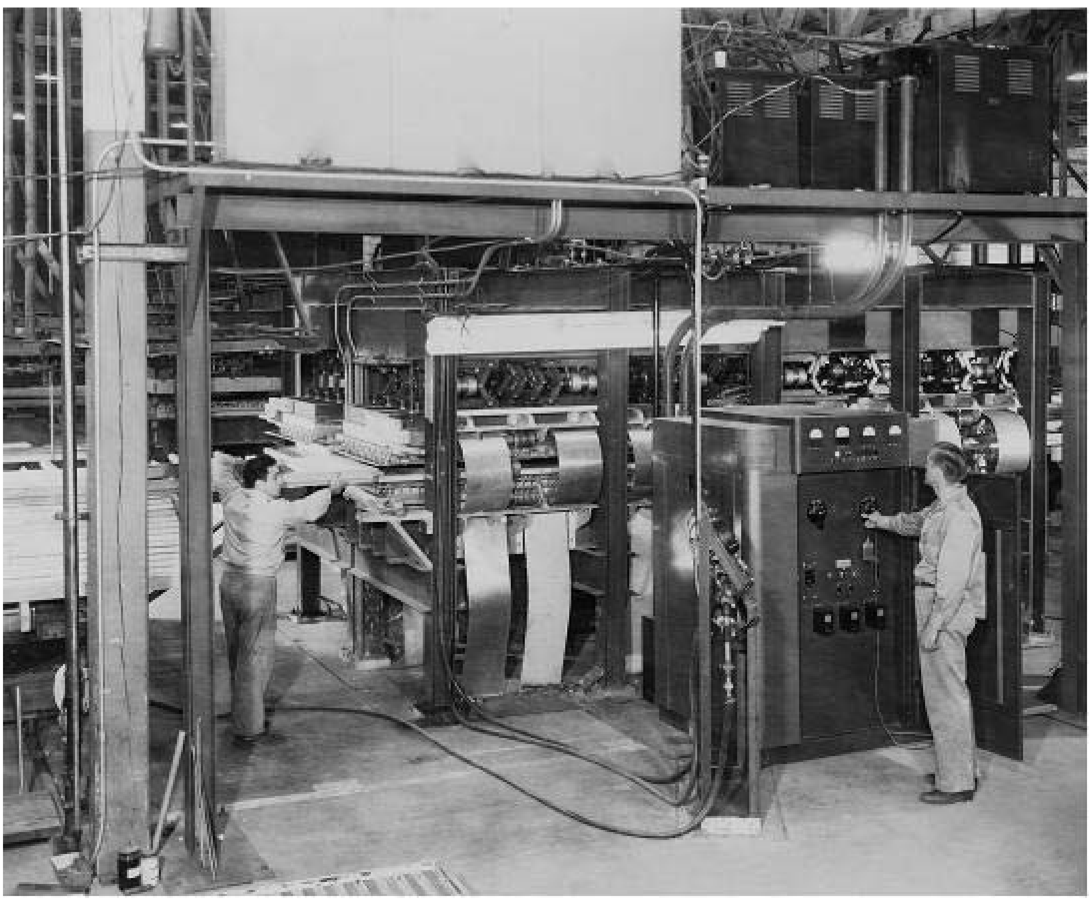

Fig. 02 General Panel Production (Copyright Akademie der Künste Berlin)

1969: The turning point towards robotic Construction 40 years ago?

Konrad Wachsmann's last research project at USC (University of Southern California) in Los Angeles was the Weyerhaeuser sponsored LOM (Location Orientation Manipulator) project between 1969 and 1971. 10 Years after he published his famous book “Turning point of building” he investigated on “motion in time and space”. In October 1989 Fritz Haller, who worked between 1966 and 1970 with Wachsmann, welcomed me at the university Karlsruhe by handing me over a video of the LOM saying:”You go on with it!”The LOM had 7 DOF (degrees of freedom) – as compared to 3-4 DOF of the UNIMATE robot by Joseph Engelberger and George Devol 10 years earlier.

The 7 DOF were realized by 3 orthogonal translatory, 3 Euler angular and 1 polar rotations. Not until recently had there been any 7 DOF industrial robots introduced by Mitsubishi Heavy ind., Yasukawa /

Motoman, DLR, KUKA and Schunck etc. . The 7 DOF kinematic redundancy enables human arm like manipulations resulting in ever broader applications even in ill defined environments.

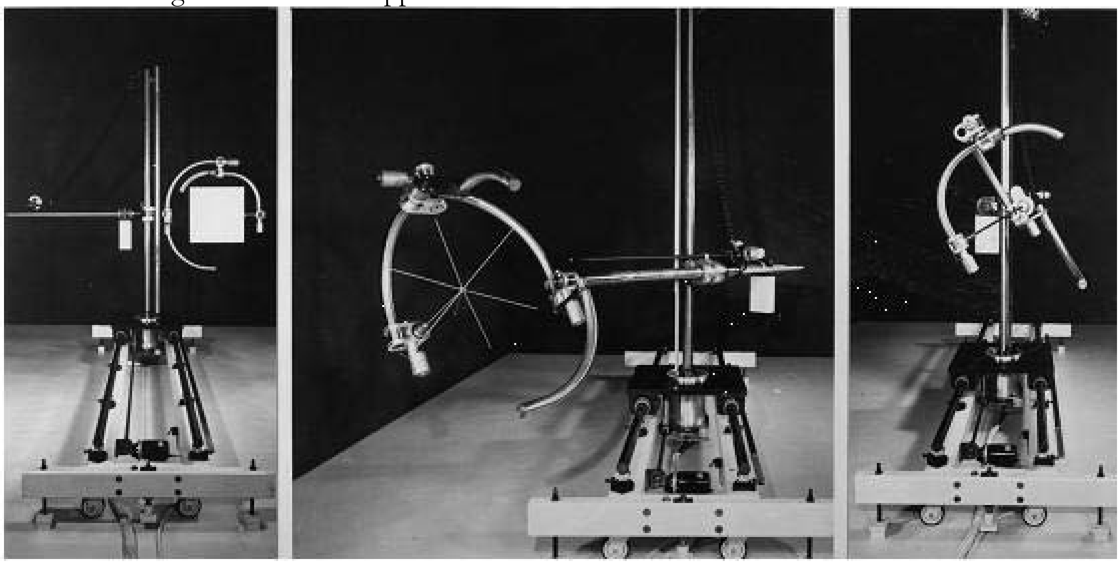

Fig.03 LOM (copyright Akademie der Künste Berlin)

1979: The turning point towards automated construction 30 years ago?

About 30 years ago several groups in Japan began investigating the potential application of construction robotics and over 100 prototypic robots had been build and tested. During my stay in Japan between 1984 and 1989 I analyzed about 50 robots and proposed the notion of robot oriented design of construction products and processes in order to facilitate future construction robotics deployment.

The motivation driving robotization in construction was lack of skilled labor, dangerous-dirty-dull working conditions, no cheap foreign workforce available, high accident and death rates, poor construction quality, time and cost overrun and poor image of construction and building trades in the public opinion.

After a decade of construction robotics development and deployment, the construction industry enjoyed a positive image, social security costs had been reduced, young motivated brightly minded people dreamed of constructing buildings with robots.

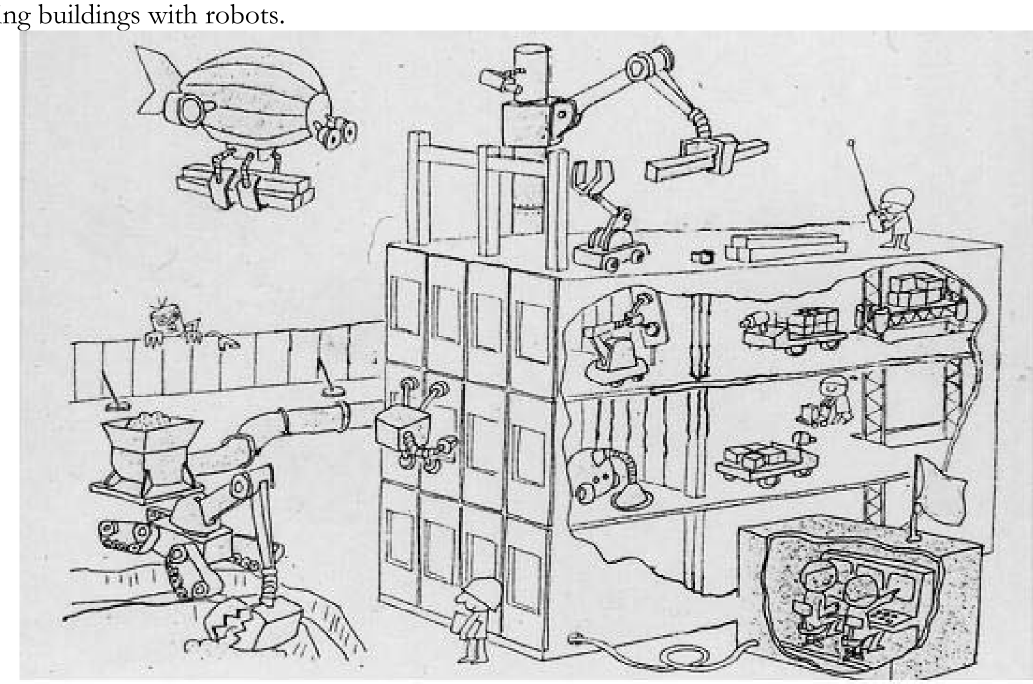

Fig. 04 (AIJ, 1984, Bock)

1989: The turning point towards automated con- and deconstruction 20 years ago?

Three years ago Dr. Paetzold of the "Deutsche Museum" asked me to take a look at a strange mechanism built by the late Konrad Zuse. Having seen some parts I argued that this was an automated building construction system. In 1989 Konrad Zuse, the german computer pioneer, started building the "helixtower" . The helixtower should build itself automatically up and down. First scale models had been realized between 1989 and 1992. Two versions exist and can be seen at the german science museum in Munich. As far as I am concerned Konrad Zuse had in mind assembling and disassembling any kind of building structure automatically.

Being aware of his background as a civil engineer who worked since 1935 for the Henschel aircraft company, I believe that he combined his knowledge of the first computers, which he build since 1936, with the knowledge of lightweight aluminum construction which he probably acquired during his job at Henschel aircraft corporation. Especially the Z 1 -his first computer with its control unit, programming unit and storage devices- in combination with aluminium light weight components, rotational parts magazines and cylindrical up- and downlift mechanism by spiraling rotation converged in his last invention of the helix tower.

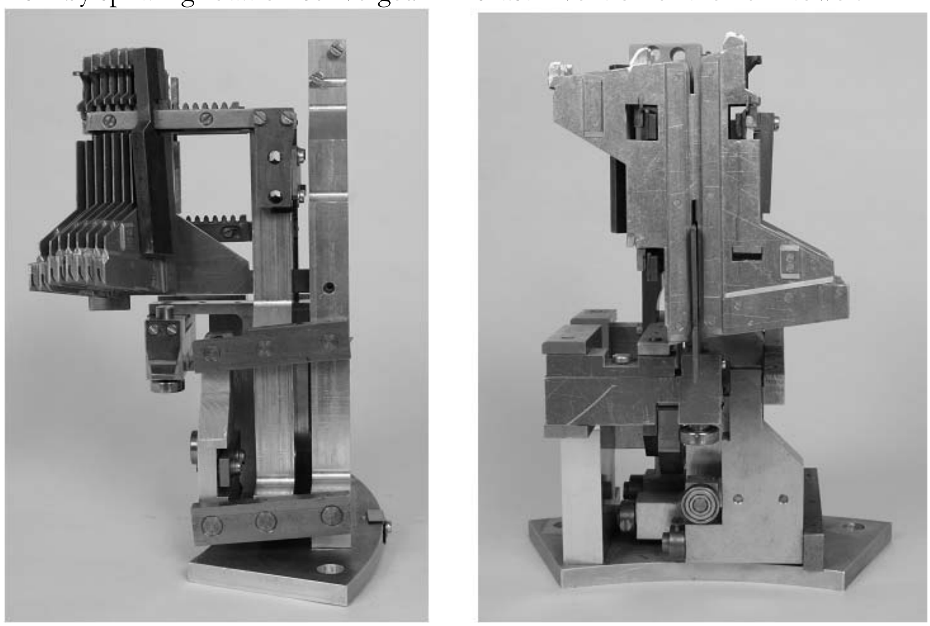

Fig.05 Helixtower (copyright Deutsches Museum);

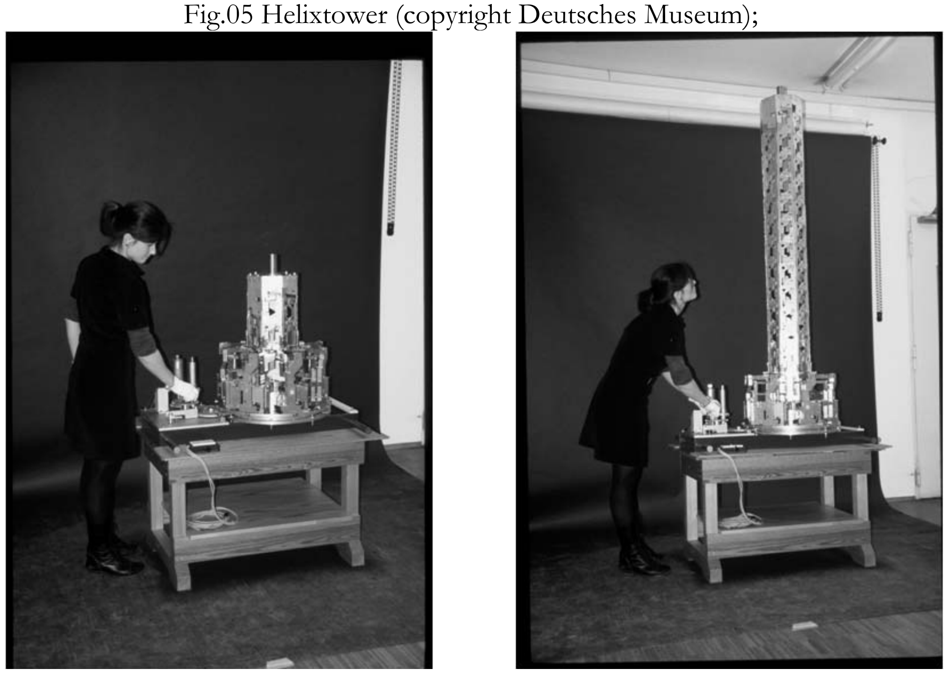

Fig.06 Helixtower, Konrad Zuse (copyright T. Bock)

Helixtower is an automated building construction system similar to Kajima's Amurad automated building construction system of the 1990'ies and the" Daruma otoshi" deconstruction (disassembly-recycling) system of 2008. The helixtower could not just assemble itself but also disassemble itself automatically.

1999: The turning point towards ambient robotics?

In modern times the average life span of a human being has increased substantially mainly due to the higher living standards. This change brings about new challenges for the area of assisted living and the functionality of relevant living space. Current birth rates are not in tune with the requirements of this aging population, leading to a long-term lack of financial provisions as well as lack of appropriate manpower. This demographic revolution requires new socio technical solutions

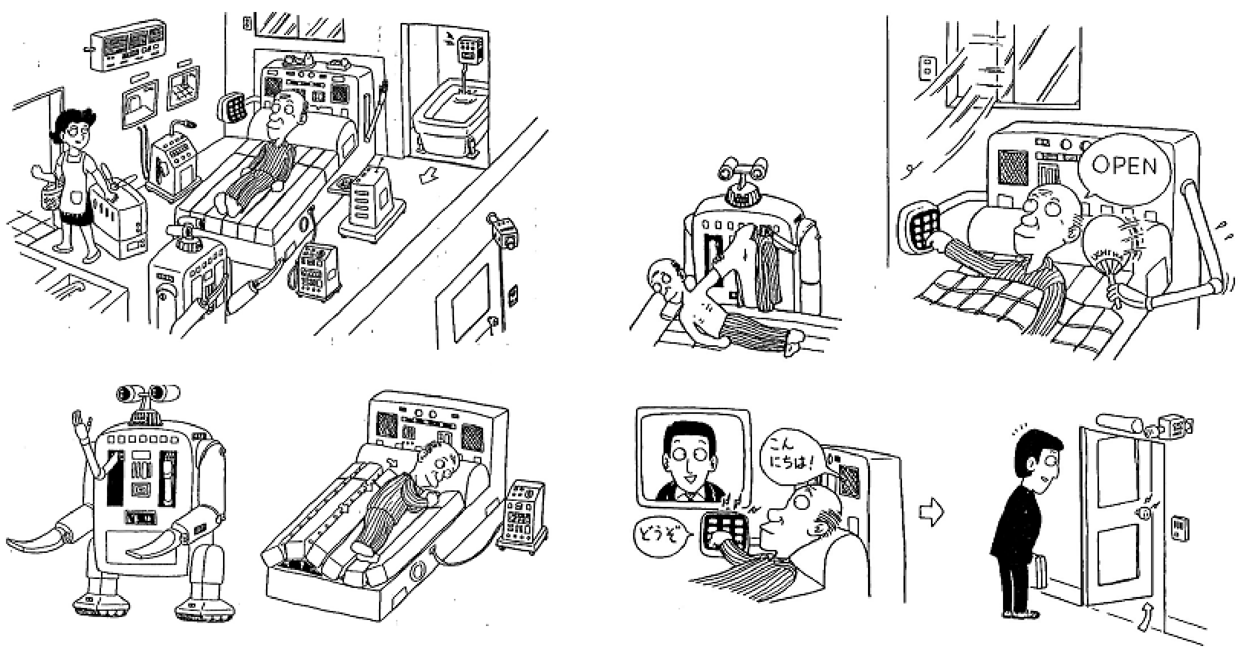

Fig. 07 Sketches showing: Life Support System, by T. Bock, for Japan Science Society1985/8 Sketches: Copyright © by Prof. Dr.-Ing./Univ.Tokio T. Bock

There is a strong tendency of the elderly to stay in their familiar habitat. Technological advancement in the assisted living industry is currently vastly outpacing architectural effort to create effective harmonised living environments. It is important to include these long-term requirements at an early stage of real estate development to overcome higher costs at later stages and possible lack of functionality.

Frontier scientists, engineers, sociologists, architects, robotic specialists, people from the areas ICT, mechatronics and microelectronics, service scientists and even people from the field of medicine, psychology and sociology have to join collaborative and highly interdisciplinary workgroups to develop acceptable ambient robotic environments.

2009: Turning point towards urban robotics

Above mentioned demographic changes in major industrialized countries the ambient robotics development will further permeate into urban environment by robotic cars and human-robot-car-city communication. A sensor network will support intelligent robots servicing in daily human life environment. One sensor network is being developed in the framework of the robot town project. The goal of robot town is to enable robots to execute various tasks for ordinary human life by implementing human tracking by vision systems, distributed sensors and RFID tags thus creating an environment well structured in informative way.

Fig.08 Robot Town (copyright Tsutomo Hasegawa)

2019: Turning point towards space robotics

The planning and building in the aerospace questions the methods of planning and building on earth. To learn anything about space-related building means to think in closed systems. A space station works completely self-sustaining.

The methods of prefabrication, of compact transporting, of modular building and of modification could give an inspiration for the methods of building on earth. Every transaction of execution has to be planned very carefully because nobody could quickly return to earth just to get any forgotten material or tools. At each terrestrial construction site much time is wasted for bringing and taking tools and material.

As space-related building is very expensive, nobody can waste space easily. Because of the zero gravity space can be used ideally in three dimensions, not only on the base side. Every room is multifunctional; the living room is working place, bedroom and dining room at the same time. In this point of view we can question our room concepts on earth and reduce our environmental waste of land. So if we are able to plan, to build and to run a space station, we can also build more ecologically.

2029: Turning point towards infra free life

Long- run missions in the aerospace call for a new idea of supply. The production of nourishment as well as water and air conditioning are tasks which massively influence the design of future space stations. It has to get by with the material and food which it can carry along. Because of the transporting system (load capacity of a skyrocket is about five tons) and the resulting restrictions contemporary space stations are formed by a high rate of prefabrication and an appropriate modular way of light weight construction.

Beside the technical solution biological answers have been considered for over 50 years by Russian scientists (BIOS-3), the Americans by building the biosphere 2 in the desert of Arizona and Japanese authority by biosphere J. Biological processes will shape the architecture of space stations in the future. Autonomous, self reliant and sustaining buildings will avoid energy loss due to infra free entities that generate and recycle habitats own ressources. A long-run mission of space ship earth becomes only imaginable, if technical products get more similar to life sciences or if we utilize organic products in a self sustaining way.

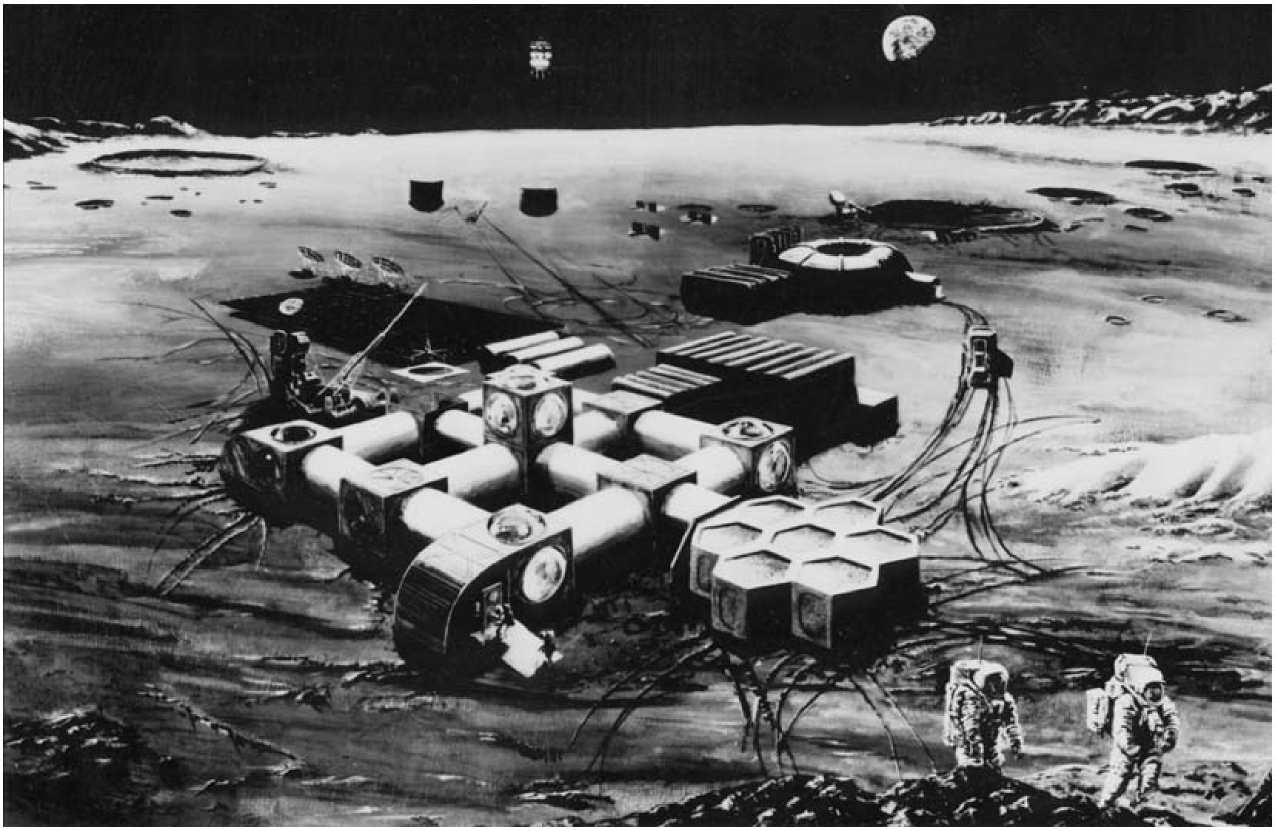

Fig.09 Space Colony (copyright Shimizu)

Literature

[1] S.Anilir, T.Bock, T.Linner, H.Suay, Application of Infra-Free Motherboard (IFM) in a Decentralized Community for a Transformable and Real-time processing Multidirectional Energy Supply Network, May 2009

[2] T. Bock: Das Dach wird zuerst gebaut und das Erdgeschoß zuerst rückgebaut, in: Volume 84, Bauingenieur, Springer ed., Feb. 2009, ISSN 0005-6650

[3] T. Bock; T. Linner: Service Oriented Architecture, 2nd AAL Symposium VDE, Berlin, 2009

[4] Nora Eibisch: Helixturm von Konrad Zuse, Diploma Thesis, TU Munich, 2009

[5] T. Hasegawa, K. Murakami: Robot Town Project, 3rd URAI 2006

[6] Bock, Thomas; Matsumura, Shuichi: Rojin Oriented Design for Architectural Life Support System. - In: Proceedings POLIS/BAS Conference "Universal Design for Buildings: Tools and Policy", Brugge/Gits 16./17.11.06

[7] T. Bock: Robotic Gerontotechnology, Research Project for Japan Science Society, TU Munich, Germany, 2000

[8] Yukio Hasegawa: Robotization in Construction, 10.June 1999, ISBN 4-7693-2145-7

[9] Life Support Sytem (LSS 3), Research report for Japan Science Society, Prof. Thomas Bock, University of Karlsruhe, Germany, 1992

[10] Otto Maier: Die räumliche Syntax, Dissertation , Universität Karlsruhe, 1989

[11] Bock, ThomasL'enjeu des robots et des automatismes- Avances pour le genie urbain, in: Ecole nationale des ponts et chaussees, Laboratoire techniques, territoires et societies unite associee au CNRS, UA 1245, La courtine, BP 105, 93194 Noisy le grand, Cedex, (CRIIF, UPMC , Jussieu, Paris), (Franzšsisch)

[12] T. Bock: Robot Oriented Design, SEKO, Shokokusha Publishing, Tokyo, May, 1988