TERRESTRIAL BENEFITS OF RESEARCH ON EXTRATERRESTRIAL CONSTRUCTIONS

Committee on the Peaceful Uses of Outer Space

Scientific and Technical Subcommittee

Forty-eighth session
Vienna, 7-18 February 2011

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Definition of (civil) engineering

Thomas Tredgold, 1828

"That species of knowledge which constitutes the profession of Civil Engineering; being the art of directing great sources of power in Nature for the use and convenience of man, as the means of production and of traffic in States both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange; and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purpose of commerce; and in the construction and adaptation of machinery; and in the drainage of cities and towns."

A SMALL WORLD
First environment of humans was a few kilometers around their habitats. They were exploiting the resources in that environment. They knew the characteristics of the “nature” which was prevailing in that area.

As their environmental area got bigger, the resources became richer and the humans met new natures. Increased richness enabled humans to discover larger areas thus to enlarge their environmental area.

New natural conditions made them more flexible and more powerful to deal with new difficulties thus increasing their technological abilities.

GLOBALIZATION

This spiral of

Increased Environmental Area <> Increased use of resources

and

higher level of technology

more powerful economy

has continued until now so that we have finally reached at the point of using the term

“globalization”

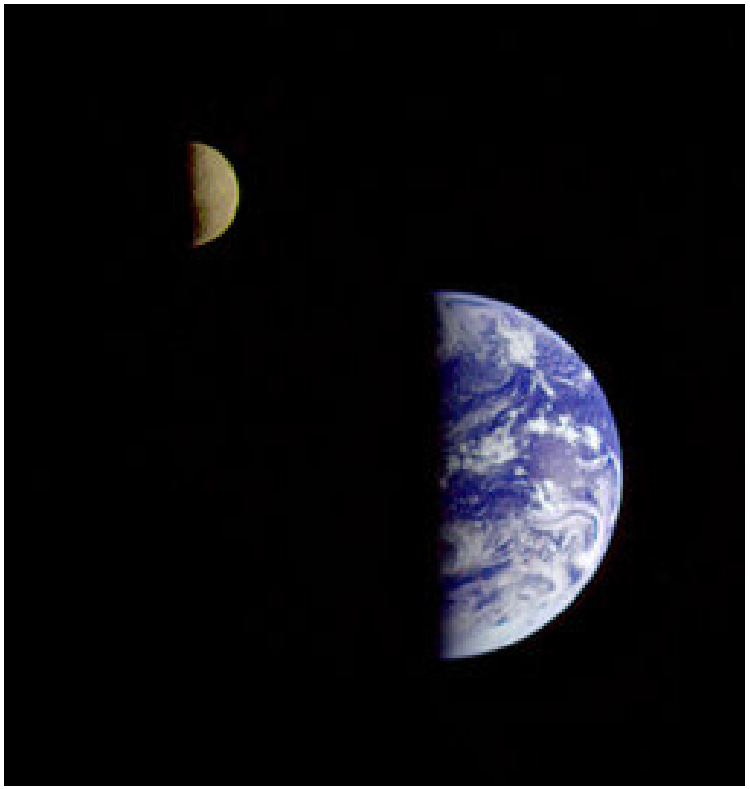
OUR WORLD NOW IS THE WHOLE GLOBE.
WE ARE NOW CONSCIOUS THAT WE ARE LIVING ON A GLOBE IN 3 DIMENSIONS

The Earth is the Cradle of Mankind, but one cannot expect to remain forever in the cradle.

Konstantin Tsiolkovsky

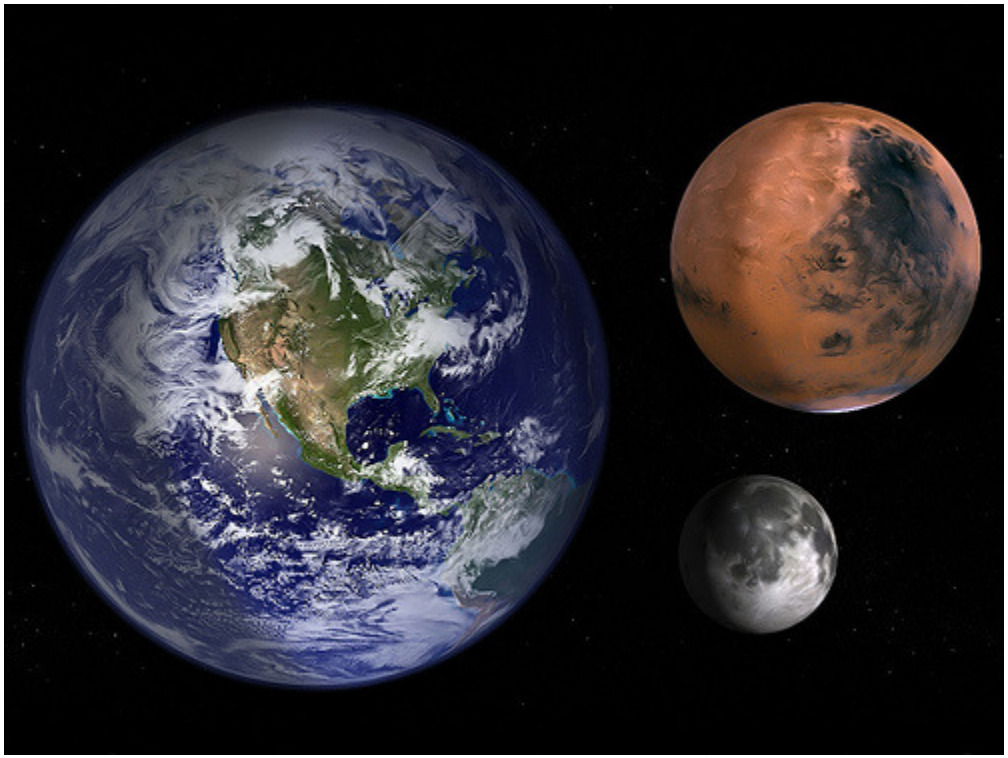
SPATIALIZATION - WORLD 2050

This picture of the Earth and Moon in a single frame, the first of its kind ever taken by a spacecraft, was recorded at September 18, 1977, by NASA's Voyager 1 when it was 12 million km from Earth.

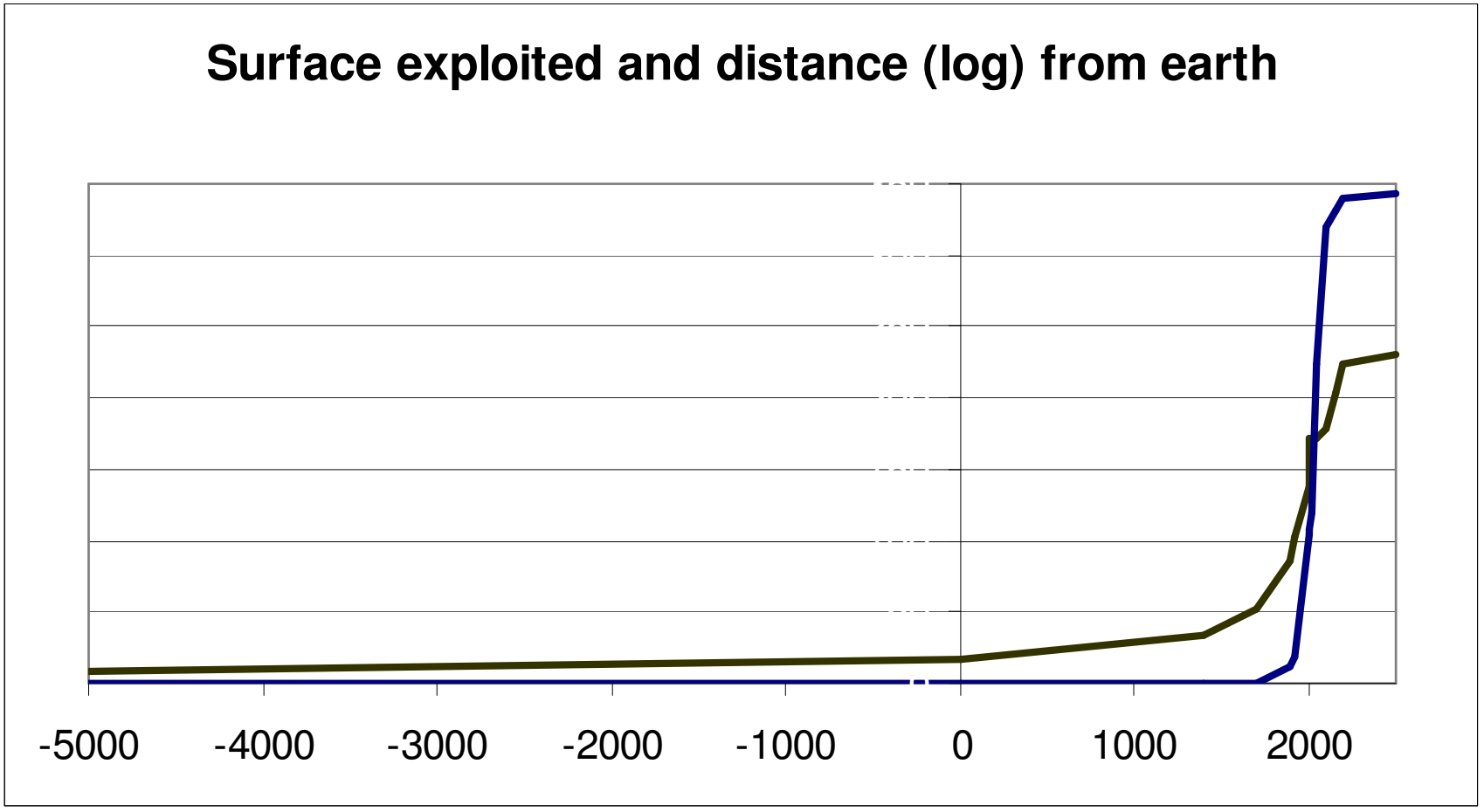


SPATIALIZATION - WORLD 2100

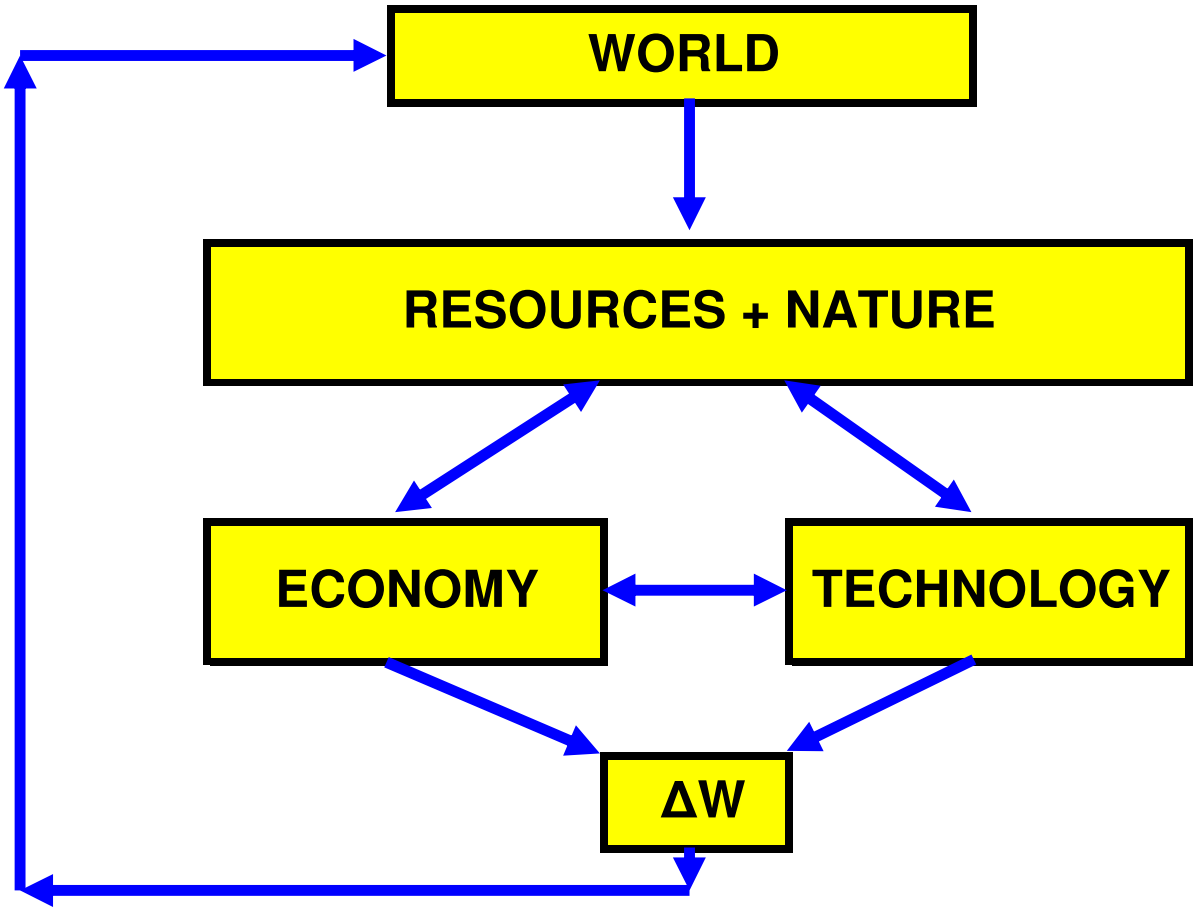
- Earth
- Moon
- Mars
- Satellites of Mars
- Space between Earth and Mars



Globalization > Spatialization



The spiral of
WORLD <> ECONOMY & TECHNOLOGY



Man goes everywhere he can go

- So, we can look to “space research” simply as a new attack to increase the dimensions of our world, a push outward of existing frontiers.

- This means that it is a natural phenomenon. As history has shown all through the passed millennia, mankind will stop at no boundaries. On the contrary, humans will always go beyond, following the motto

- “Man goes everywhere he can go”.

Space Research is a natural continuation of the historical activities starting from primitive habitats to globalization

- It seems that, until now, there have been more than 30000 innovations coming from man's attack towards skies beyond atmosphere.
- Some of them are directly related to space applications, but most of them are indirectly related to space research.
- Many of them have helped to give birth to unexpected by-products which can be used in areas not related to space affairs, thus benefiting also humans who are not related to space affairs in no way.

- This means that space research is not a single dimensional activity. On the contrary, it is a multi-dimensional task if not infinite dimensional. This is true for the aims and for outputs at the same time.

- The feedback of space research is very important for all mankind.

Feedback to Earth

"We went to explore the Moon, and in fact discovered the Earth."

Eugene Cernan

Apollo 17 astronaut

Feedback of Space Reseach

- Space research is a multi-dimensional task. One aspect of it is founding habitations, bases on the Moon, Mars, and other extraterrestrial bodies.
- Construction is an important item in founding these outposts.
- When performing these operations, many innovations will be done.
- These innovations will certainly benefit humans' terrestrial life.

Use of in-situ materials

- Carrying 1 kg of material from Earth to Moon costs about 20000 US$. Even if this rate could be reduced in the future, it will still be high and always risky.

- So all possible ways of making maximum usage of existing materials will be tried on the Moon and Mars.

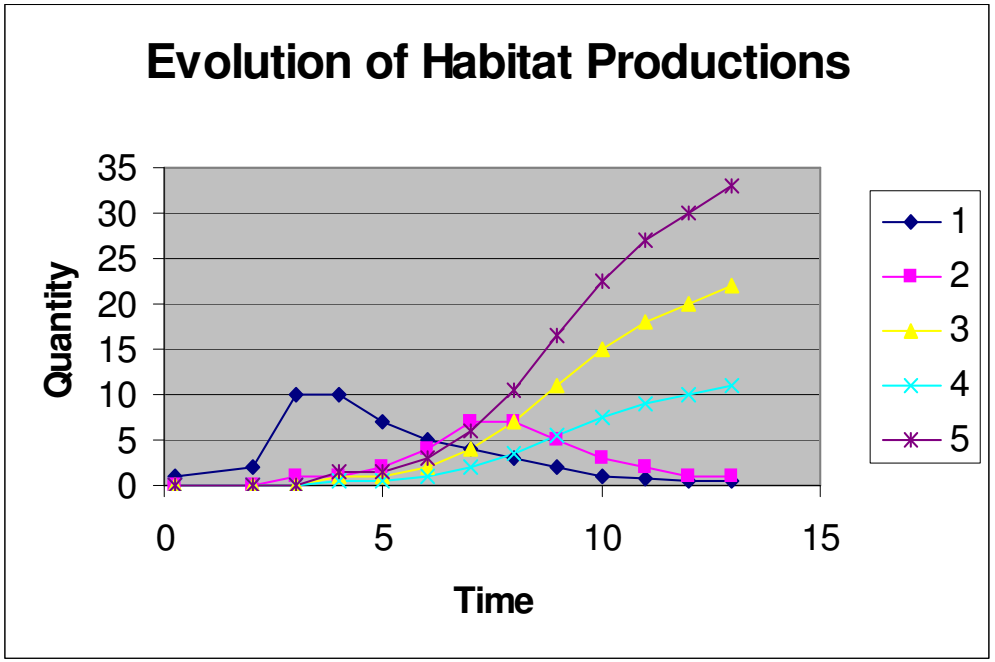
Use of in-situ materials

Three possibilities:

1. Use raw in-situ material as much as possible.
2. Find effective and simple ways of treating in-situ material for being used in constructions.
3. Develop techniques for advanced treatment of in-situ materials for extracting elements and minerals.

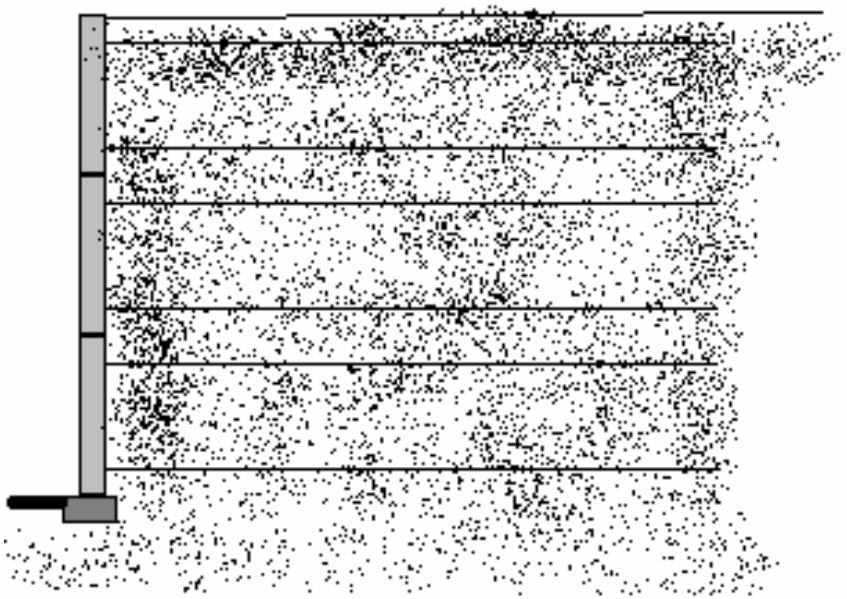
Use of in-situ materials

	Resources		Plant	
	Earth	Moon	Earth	Moon
1	√		√	
2	√			√
3	√	√		√
4		√		√
5	√	√	√	√



Use of in-situ materials

Reinforced Regolith



A better understanding of structures

- On Earth > Primordial loads are gravitational. Environmental live loads (earthquakes, wind, snow, ...) may also be important.

- On Moon > Gravitational loads are as important as on Earth due to shielding materials. But effects coming from inside pressure is much more important. Cracks are not allowed.

A better understanding of structures

Different types of structures and different concepts:

- Constructions in lava tubes
- Habitats embedded in regolith
- Tensegric structures
- Structures with reinforced regolith walls
- Inflatable structures
- Extensive use of prestressing
- Structures with no stress concentrations

Robustness

- Dealing with uncertainties, unattended effects.
- Robust design, robust structures are somehow new subjects on Earth.
- In space every thing must be robust. Scheduling, design, construction, maintenance must all follow the principles of robustness.

Waste treatment

- There will be a very advanced waste management system. All liquid, solid and gaseous wastes will be treated to a maximum extent and recycled for repeated use.

Nonlinearity

- On Earth, construction materials are used in linear zone for being on the safe side and also due to the computational difficulties coming from nonlinearity.
- In space, we will not have that luxury. All the materials will be exploited up to their maximum limits, of course without concession from safety.

Automated construction

- Due to the difficulties and dangers in using manual workmanship, automated mining, earthwork and construction techniques will be advanced and used on extraterrestrial bodies. Many kinds of robots will be developed for special works. Construction industry will be fully automated.

Special construction machines

- Special environmental lunar and martian conditions will enforce development of special construction machines:

- Electrically operated
- Fully automatical and/or telecommanded
- Lighter
- With special measures against dust

Building Information Systems

All the structures will be controlled, managed by a central management sytem.

There will be sensors measuring pressure, temperature, humidity, light, oxygen content, CO2, humidity, stresses and strains in the structures, etc. at every possible zone of the structures.

All this data will be saved and evaluated in the managing systems.

Building Information Systems

The managing system will decide on actions to be taken according to this data, taking into account the most effective use of resources (energy and materials), comfort, and security in the base.

According to the decions taken by the central management system, through actuators, the necessary actions will be taken.

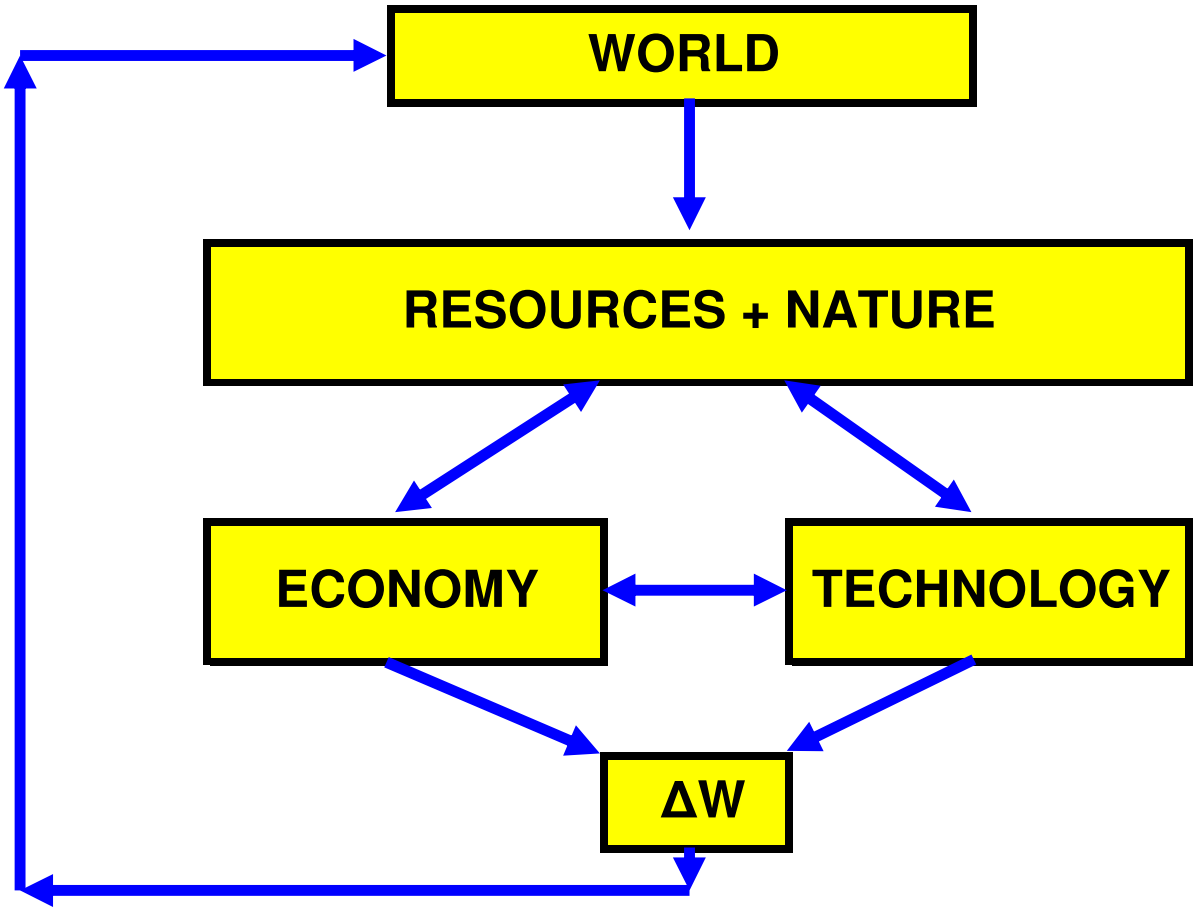
Building Information Systems

This means that all structures will be smart, or intelligent.

In fact they will be acting as robots, or in other words, as mecatronic systems.

The experience gained through these all these applications will certainly benefit terrestrial applications.

The spiral of
WORLD <> ECONOMY & TECHNOLOGY



Future and Civil Engineers

It is to be noted that, up to now, the pioneering countries have been extremely successful in their manned an unmanned operations on the moon and elsewhere in the space. It is this success that gives all mankind the hope and the security that the coming operations will also be successful and thus the thought that this pioneering work has to be followed. In this context, civil engineers will continue to do their work adopted for the new Nature and carry back their innovations to Earth.

W(new) = W(old) + ΔW

This process has always been an adventure. The one in front of us is perhaps the greatest of them. It marks the passage from globalization to spatialization.

Construction is only a small part of it. The reflexions made here are not comprehensive.

The subject has to be treated with all other dimensions.

Research on Celestial Bodies

UN OOSA – Turkey – ESA

Workshop on

"Space Technology Applications for Socio-Economic Benefits"

14-17 September 2010, Istanbul, Turkey

Working Group on Research on Extraterrestrial Bodies

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Symposium "Planetary Protection"

14 February 2011

Chaired by Professor John Rummel

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