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Space Research and the problems of data validation: Quality versus Quantity

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Abstract

This lecture deals with the history of Space Research in Russia, USA, and Europe and its present consequences for economy and ecology, especially in viewing the tension between quality and quantity of hardware and software, e.g. of special high tech products, their reliability and costs in contrast to the mass – consumer - products. The quality of the latter gets also increasing attention with the increasing number of court cases in the US because of product liability. The common and the essential differences between manned to unmanned space missions – research and applications are mentioned. In the application case especially satellite communication and navigation have been considered. Furthermore the steps from data acquisition to data validation and value added validation are described together with the increasing data growth rate problems and the DUST-2/ADLATUS concept which has been conceived to mitigate these problems. Now it also includes e-publishing – according to the Budapest Initiative of Open Access (BOIA, 2002) - an additional important step to reduce the "digital divide" between the highly industrialised and less industrialised nations. Finally the MAS/GRAS sensor combination proposed to be flown on the International Space Station (ISS) is presented as a concrete detailed example for an optimal (value added) validation. Therefore a MAS/GRAS feasibility study or a phase A study can be highly recommended, especially for non highly industrialised nations that want to participate in and significantly contribute to actual space research and relevant qualified hardware and software technologies.

[1] MPAe links:
1. http://www.linmpi.mpg.de/english/projekte/projekte1.html (MPAe research projects)
2. http://www.linmpi.mpg.de/english/links.html ; (MPAe Links)
3. http://www.linmpi.mpg.de/english/projekte/mas/ (MPAe MAS project)
4. http://www.linmpi.mpg.de/english/projekte/mas/dust-2/ (MPAe DUST-2 project)

Content

Preface

The ultimate goal of Space Research is our cosmos, which is the largest open system - in space and time -, which has also intelligent inhabitants who try to understand it, amongst others through cosmology. Today modern cosmology – however also many other science domains - call for a better balance between **Space research and Time research**, the latter also gets increasingly a subject of theology.

1. History of Space Research: Russia, USA, and Europe

The most important milestones in space research and space technology in the last century – figs. 1 and 3a - have been created by Russia and the USA, (Sputnik 1957, Apollo 1969). Cold war East – West competition and confrontation implied that (financial resources) costs were not – as today - the main limiting factor for Space research and space exploration activities. This also implied that during the cold war period optimal (highest possible) quality was the driving force which can be achieved through following the principle of "excellence for the excellence's sake".

Remark:

Quality in Space Research is characterised by: Special (single or very few) products, long-lived, (durable and reliable under interplanetary conditions), expensive, resource extensive, high capital intensive, slow capital return, i.e. it takes a longer time until the technological *(by-)products can be economically sold for daily life uses. Special Quality Assurance (QA) and Quality Control (QC) procedures have been developed in this context. They have been supplemented by intensive and expensive security procedures in context with manned space research.*

As a consequence of the oppression and isolation during the Soviet ideology (USSR), the disappointment after the lost ”cold war” , and as a consequence of the present bad economic situation the space research program of Russia is in a deep crisis. The space research program of the USA can be characterised by commercialisation respectively ”enterprise”. This brings it always closer to an everyday subject and thus its continuous budget cuts are understandable. At the beginning of the 21st century - in context with its international space research and technology program - Europe might be able to set an impulse for a new orientation of this program and thus can better justify and maintain a reasonable support than Russia and the USA. Since a trip to the "inner human space" by means of virtual reality (VR) in the cyberspace is a lot cheaper and also easier than a trip to the outer space, private and public support might further decrease for the latter if we stick to the old paths or can not make (outer) space again more attractive. Is the European (science) policy capable and ready to meet this challenge and to find a new ”in-between” for Space research between Russia and the USA? It must be located between a (Russian) antipositivism and an US ”romantic pragmatism” and might initiate a new (common) understanding for the meaning of science. The geographic location of Europe, its cultural history, and the very recent East-West experiences offer a unique chance and challenge. Will Europe make use of it? If yes, then not only a more profound (inner- and intercultural) East-West dialogue and a co-operation will be possible but also similar consequences can be expected for the North-South co-operation and the co-operation with Asia and other cultures.

Russia

The Russian rocket pioneer Konstantin Tsiolkovsky (1857-1935) who stands in one row with the US American Robert H. Goddard (1882-1945) and the German Hermann Oberth (1894-1989) and the other early Russian pioneers were strongly influenced by N.F. Fedorov. Nicolai Fedorovich Fedorov (1828-1903) was a powerful inspiration to Soloviev, Dostoevsky, Tolstoy, and a whole generation of Russians who sought to understand how modernisation connects with traditional religion and culture. His profound vision applied certain strands of Russian Orthodox spirituality to harnessing of modern technology. He argued that Russia should marshal its military and national strength toward a single goal: the conquest of nature. Conquering nature meant regulating the earth as a harmonious system. It meant controlling the weather so that harvest would be plentiful. It meant balancing nature so that all life-forms could live together in harmony. Overpopulation would cease to be a problem as humanity colonised other planets. Unique to Fedorov's vision is its guiding moral spark. Instead of basing the conquest of nature on dominance, aggression, and egoism, Fedorov shunned the notion that humans should rule the cosmos out of selfish desire for material wealth and abundance. Instead he envisioned the conquest of nature as an act of altruism. But being generous to future generations can be less than purely altruistic, for they can return the favor by acclaim of our deeds. We must regulate the forces of nature, he believed, so altruistically that we serve those who cannot possibly return our favors: we must conquer nature in order to resurrect our ancestors, the ultimate act of altruism.

The resurrection of all our dead ancestors, and it alone, provides a lofty enough ideal to mobilize humanity to explore the entire universe, including outer space. Fedorov found this thought in the Russian Orthodox Christianity. (The bodies of all human beings will one day rise again, and this resurrection according to Fedorov, will take place through the work of human beings who carry out the divine plan). Fedorov's strategy was to channel science and technology toward the reunion of all humanity. He decried the heartless positivism that builds on the sufferings and corpses of previous generations, instead seeking purely idealistic motive. Without such a high aim, a heartless science would ultimately turn against society. For him, and for many Soviet scientists inspired by him , the ultimate aim of the space program was, quite literally, nothing less than resurrecting the dead.

The Russian space research program was until now never directly subjected to commercial aspects. However, it was like in the USA an important factor in the cold war. Under the Soviet ideology it was not only the aim to conquer nature but also the hostile western ideology. The Sovoetideology have had the priority over all human as well material resources aspects. Failures in rocket launches, loss of human life in the space program and costs of experiments played a very different role than in the US - also because of the antipositivistic Russian background. Thus it was possible over a fairly long time period to fly fast simple and cheap experiments with Russian rockets. However, since several years an increasing (technical) bureaucracy prevents this more and more also in Russia - like in most other nations with space programs. Hence also in Russia the ratio of direct (practical and scientific) work in Space Research to its planning, administration, and justification has fallen below the 50% mark.

Remark:

The early NASA Space Shuttle plans looked very similar, however, many strong and rigid safety constraints for manned space research made experiments on the Shuttle even more expensive than US rocket experiments in the unmanned program., which have been more expensive than the relevant Russian ones. The recent NASA idea "Faster, cheaper, better" tries to better approach the old ideas, however, in its present interpretation in the longer term it might rather support the trend towards more cyberspace than towards (outer) space research.

USA

Remark:

When we look for the essence of a technology, we are engaging in speculation, but not in airy speculation. Our speculations involves where we plant our feet, who we are, and what we choose to be Behind the development of every major technology lies a vision. This vision gives impetus to developers in the field even though the vision might not be clear, detailed or even practical. The vision captures the essences of the technology and calls forth the cultural energy needed to propel it forward. Often a technological vision taps mythic consciousness and the religious side of the human spirit

The US space program enjoyed its most rapid development in the 1960s, culminating in the moon walk in 1969. What was the vision behind it?

The US space program was a child of the cold war. The 1961 speech by President John F. Kennedy that set NASA's goals incorporated traditional elements of myth: heroic struggle, personal sacrifice, and the quest for national prominence. Yet the impetus for Kennedy's speech came largely from without. What launched the US space program was the fear of being surpassed by the Soviets, who made a series of bold advances in space travel. The goal of the moon landing was for the United States an attempt not to be overtaken by the Soviet developments in manned space exploration. Few US Americans know about the vision of their Russian competitors in space exploration This essence was not itself technological as was pointed out in the previous chapter.

Contrast this (incredible) vision with the current US public policy. "The commercialization of space," as promoted by administrations since the late 1970s, offer civilian entrepreneurs new opportunities for investment. To cover the naked self-interest, a mythic notion from US history adds the sense of a new frontier. As a mere resource for commerce. Space holds little

allure, but a frontier beyond earth adds adventure to the hope for personal gain. This vision draws the spirit of **enterprise.**
In fact, this last word, **enterprise,** shows us where the commercialization of space falls short. Commercialization fails to touch the essence of space exploration, for commercial interest will and have to neglect the long term research needed for space science. Commercialization also drives up the cost of information derived from space exploration so that data from space will be hardly available to small business, universities, farmers, state and local governments, and developing countries. In short this kind of exploration envisions no future, only short range profit.
Remarks:
1. *So it was decided that NASA should devote about 20% of its resources for (basic) research. This makes also clear that longer term trend observations respectively environmental monitoring from space will and cannot be done by NASA. These activities are mainly carried out in the US under the responsibility of the department of commerce.*
2. *The fact that in the Federal Republic of Germany there is nothing similar - except the operational weather service within the department of transportation - implies that the situation for the acquisition and storage of long term environmental data is worse than in the US.*
3. *This also implies that data centers which like to make available data for their users from basic (short term) space research and (quasi)-operational space research have to use in the US the two complementary sources, e.g. NASA and NOAA.*

Many technical people today also take enterprise to be the proper name in a science fiction myth , that of the starship Enterprise in "Star Trek", the popular science fiction television serious about twenty-first-century space travelers. For hundreds of technicians, the space program flies on the imaginative wings of Gene Roddenberry's brainchild, born on September 8, 1966, when the TV show was first aired. But Roddenberg was not Fedorov. The sage of Pasadena created no unifying vision to direct humanity "where no one has gone before." His fictional productions treated only a motley collection of profound moral questions pertaining to human behavior qt any time, any place. But despite the limits of its lineage, "Star Trek" showed us more truly the esoteric essence, the real meaning, of space exploration than did government statements on the commercialization of space. The essence of the US American space program, its heart and soul comes from "Star Trek" (Heim, page 122, 1993).
Along with its cargo of imaginative treasures, the starship enterprise brought the Holodeck. The Holodeck is familiar furniture in the vocabulary of virtual-reality (VR) pioneers. For most people Holodeck portrays the ideal human-computer interface. At the MIT Media Lab, leaders such as David Zeltzer avoid the term virtual reality not only because of the specter of metaphysics it evokes, but also because of the large promises it raises. During a conference in 1992 Zeltzer made a remark like this: "True virtual reality may not be attainable with any technology we create. The Holodeck may forever remain fiction. Nonetheless, virtual reality serves as the Holy Grail of research." Zeltzer was calling up a mythic image far more ancient and infinitely more profound than "Star Trek". Star Trek has, after all become the stuff of trivia: " Star Trek ties and boxer shorts etc. The ancient Grails legend reaches back to pre-Christian times. The Grail has always been a symbol of the quest for a better world.
Might this be the reason why VR which is more related to our "inner space" than to the outer space which was and still is the object of our "classical" space research draws our attention slowly away from the "outer space" and then of course reduces also the private and public support for it?
Remark
Positivism expects not only from science that it only relies on facts but also that it restricts to it and the relevant relationships and laws. According to neo-positivism only that what can be

empirically verified. Therefore metaphysical statements are as senseless as those concerning values and norms (standards). Valuation is only an expression of emotion and necessaries exist only in the domain of logic. The Russian antipositivism has led to the fact that during the Sovietideology science was put near to religion. This sometimes implied that discussions as known between more positivistic western scientists were replaced by disputes where justification of results is replaced by a statement with the quality of a **doctrine**.

The role of Europe

The most important milestones in space research and space technology in this century have been created by Russia and the USA, (Sputnik 1957, Apollo 1969). As a consequence of the oppression and isolation during the Sovietideology (USSR), the disappointment after the lost ”cold war” , and as a consequence of the present bad economic situation the space research program of Russia is in a deep crisis. The space research program of the USA can be characterized by commercialization respectively ”enterprise”. This brings it always closer to an everyday subject and thus its continuous budget cuts are understandable. Common for both programs is:

- The large budget cuts
- The unclear understanding of the meaning of modern science in general and of space research in special and the fact that virtual reality (predominantly related to human "inner space") seems to outgrow the interest in the "outer space" and this might lead to a further reduction of the "classical" (hitherto) space research activities.

Will Europe just amplify these trends or use the chance for a new orientation between the antipositivistic Russian view and the romantic pragmatic view of the US? If the chance is used it will very likely also lead to a new (common) understanding of science which might counteract the growing public hostility towards modern empirical science, which suffers right now more from an attitude of **arbitrariness and not binding** than from a lack of discussion about its meaning and implications**.** It will also stimulate more and better innovations which will support to reduce our present world wide socio-economic-ecoloical crisis. Only with this new understanding of modern science can we expect that the fight/dispute between the adherents of manned space program (research) and their opponents who support unmanned space research will be terminated. At present the tension increases - at least in the Federal Republic of Germany - because of the budget cuts for unmanned space research in favor of the manned space flight program, especially the construction of the International Space Station Alpha (ISSA). Since a trip to the "inner human space" by means of virtual reality (VR) in the „cyberspace“ is a lot cheaper and also easier than a trip to the outer space, private and public support might further decrease for the latter if we stick to the old paths or can not make (outer) space again more attractive. At least what concerns the world wide "outer space" activities within the international space research program Europe might act as a catalyst for a new orientation of it which might not only increase its public and private attractivity but also significantly improve the international/intercultural (practical) co-operation. Especially because of this the author, a German European citizen, hopes that not only Europe will grasp this chance (Hartmann, 1998).

2. Between Quality and Quantity: High tech for Space Research needs quality assurance

2.1 Background

Talking about **quality versus quantity** in our western culture we inevitably run into the antique Greek sorites paradox, those days more known as a puzzle – amongst many others. This paradox attracted little subsequent interest until the late nineteenth century when formal

logic once again assumed a central role in philosophy. With the demise of ideal language doctrines in the latter half of the twentieth century interest in the vagaries of natural language and the sorites paradox in particular has greatly increased.
The name 'sorites' derives from the Greek word *soros* (meaning 'heap') and originally referred, not to a paradox, but rather to a puzzle known as *The Heap*: Would you describe a single grain (quantity) of wheat as a heap(quality)? No. Would you describe two grains of wheat as a heap? No. You must admit the presence of a heap sooner or later, so where do you draw the line where the (irrational) transition from quantity to quality occurs?
Remark
The sorites paradox is the name given to a class of paradoxical arguments, also known as little-by-little arguments, which arise as a result of the indeterminacy surrounding limits of application of the predicates involved. For example the concept of a heap appears to lack sharp boundaries and, as a consequence of the subsequent indeterminacy surrounding the extension of the predicate 'is a heap', no one grain of wheat can be identified as making the difference between being a heap and not being a heap. Given then that one grain of wheat does not make a heap, it would seem to follow that two do not, thus three do not, and so on. In the end it would appear that no amount of wheat can make a heap. We are faced with paradox since from apparently true premises by seemingly uncontroversial reasoning we arrive at an apparently false conclusion. This phenomenon at the heart of the paradoxes is now recognised as the phenomenon of ***vagueness.*** *Once identified, vagueness can be seen to be a feature of syntactic categories other than predicates, nonetheless one speaks primarily of the soriticality of predicates.*
Sorites arguments of the paradoxical form are to be distinguished from multi-premise syllogisms (polysyllogisms) which are sometimes also referred to as sorites arguments. Whilst both polysyllogisms and sorites paradoxes are chain-arguments, the former need not be paradoxical in nature and the latter need not be syllogistic in form.

4. Between manned Space research and unmanned Space Research

Introduction

It is not possible to justify Basic research and Space research with quick capital return. It is a cultural endeavor and an investment in and for the future. However, regarding Space research and the related Research and Development (R&D) activities it contributes to today's quality of life in the following way: a) through necessary and possible global monitoring, b) through fascination and (national) prestige, through the "example function" of the result from projects executed under the motto **"excellence for the sake of excellence**" (Hartmann, 1996c,d)
A leading role in **today's** market economy implies to comply with the main recent economic trends and the relevant results from **Research and Development (R&D)**, which however originated several decades ago because of the so called **reaction time delay** effect. A leading role in **tomorrow's** market economy implies to observe and use the present results, but **simultaneously** to invest in complementary R&D projects, especially those which are conceived under the motto "**Excellence for the sake of Excellence"**, since this will "produce" the optimal innovation probability. **Space Research projects** are good candidates for it.
In times of weaker (national) economies the (governmental and often also private) R&D funding in general decreases – though it should, according to biocybernetic rules, not decrease – and thus forces us to strive for better disposal knowledge, which comprises the development of **"smarter processes, systems, and products".** The less resources (funding) are available, the more must be invested in the – hitherto fairly disregarded "further development" of so called "prototype" or old processes, systems, and products. Economizing the R&D activities

implies that the two should be better balanced. This is the major consideration in a proposed **DEREMOTOX** pilot project. See figures 2, 2a, 3a, b, c, and Hartmann et al. (2001).

4.1 Manned Space research

Manned space research or exploration

A major statement of the proponents of the manned space exploration reads as follows:
"One of the next important steps in the human evolution is the exploration of the world beyond earth, to develop and to preserve our kind. Science proved that it is very hard to find an earth-like planet. Until now there is only one we now, and it is very fragile. Since several years many probes have been send into space, did land or are orbiting a planet or its satellite, they gave us a lot of information. High tech devices were made to see millions of light-years deep in space. Manned spacecrafts are in use, and did even land on the moon. Now we must find out how we can improve our possibilities to survive in space, and to extend our frontier. One day we will live on a second home planet and it will be our new colorful generation, developed by them who understand and who are already there with their spirit".
A major inevitable step towards these goals has been done with the International Space Station (ISS) which is public described as follows:
"The International Space Station (ISS) is the largest and most complex international scientific project in history. And when it is complete just after the turn of the century, the the station will represent a move of unprecedented scale off the home planet. Led by the United States, the International Space Station draws upon the scientific and technological resources of 16 nations: Canada, Japan, Russia, 11 nations of the European Space Agency and Brazil. More than four times as large as the Russian MIR space station, the completed International Space Station will have a mass of about 1,040,000 pounds. It will measure 356 feet across and 290 feet long, with almost an acre of solar panels to provide electrical power to six state-of-the-art laboratories. The station will be in an orbit with an altitude of 250 statute miles with an inclination of 51.6 degrees. This orbit allows the station to be reached by the launch vehicles of all the international partners to provide a robust capability for the delivery of crews and supplies. The orbit also provides excellent Earth observations with coverage of 85 percent of the globe and over flight of 95 percent of the population. By the end of this year, about 500,000 pounds of station components will be have been built at factories around the world"

More information on manned space research can be found via the following links:
http://home2.pi.be/tristar/space.htm
http://www.cet.edu/earthinfo/remotesens/remotesens.html
http://www.oma.be/BIRA-IASB/Public/PubServ/Astronautics/Astronautics99.en.html
http://www.itsf.org/resources/factsheet.php?fsID=68
http://www.ufrsd.net/staffwww/stefanl/ssystem/jupiter/probes/manned.html
http://www.ufrsd.net/staffwww/stefanl/ssystem/jupiter/probes/unmanned.html

MPAe links:

http://www.linmpi.mpg.de/english/projekte/mas/ (MPAe MAS project)
http://www.linmpi.mpg.de/english/projekte/mas/dust-2/ (MPAE DUST-2 project)

4.2 Unmanned Space Research

Major applications domains and problems for unmanned spacecrafts

1. **Lunar and Planetary Spacecrafts**
2. **Space Science and Space Observatories**

3. **Communications Satellites**
4. **Remote Sensing and Earth Observation**
5. **Military and Navigation Spacecraft**

Major problems of spacecraft experiments

1. **reliable inflight calibration complicated, sometimes even impossible**
2. **need for non linear data compression aboard leads in general to an irreversible data processing product**
3. **validation possibilites with co-located and co-timed experiments from other satellites are scarce**

See also Table 2

Informations on unmanned space research can be found at:
http://roland.lerc.nasa.gov/~dglover/sat/craft.html
MPAe links:
http://www.linmpi.mpg.de/english/projekte/projekte1.html (MPAe research projects)
http://www.linmpi.mpg.de/english/links.html ; (MPAe Links)

Further important links for both space research domains:
http://www.nasa.gov
http://carstad.gsfc.nasa.gov/RSTutorial/start.html
http://carstad.gsfc.nasa.gov/RSTutorial/Intro/Part2_1c.html
Planetary Imagery Sites at the Lunar & Planetary Institute:
http://cass.jsc.nasa.gov/library/LISTS/img_file.html
JPL's Imaging Radar Home page:
http://southport.jpl.nasa.gov/education/classroom/

1. http://roland.lerc.nasa.gov/~dglover/sat/craft.html
2. MPAe links:
http://www.linmpi.mpg.de/english/projekte/projekte1.html (MPAe research projects)
http://www.linmpi.mpg.de/english/links.html ; (MPAe Links)

Planetary Imagery Sites at the Lunar & Planetary Insitutute:
http://cass.jsc.nasa.gov/library/LISTS/img_file.html
JPL's Imaging Radar Home page: http://southport.jpl.nasa.gov/education/classroom/
(Compilation see tables 1 and 2)

Some URLs for Laser systems and Space Research

http://aesd.larc.nasa.gov/GL/glf/lsb_over.html
http://aesd.larc.nasa.gov/GL/tutorial/glossary/gloss.htm
http://aesd.larc.nasa.gov/GL/glf/papers/rpub_mnu.htm
http://www.sti.nasa.gov/tto/spinoff1997/er3.html

Remote sensing
A formal and comprehensive definition of applied remote sensing, as it is customarily formulated to include determination of geophysical parameters, is:

The acquisition and measurement of data/information on some property(ies) of a phenomenon, object, or material by a recording device not in physical, intimate contact with the feature(s) under surveillance; techniques involve amassing knowledge pertinent to environments by measuring force fields, electromagnetic radiation, or acoustic energy employing cameras, radiometers and scanners, lasers, radio frequency receivers, radar systems, sonar, thermal devices, seismographs, magnetometers, gravimeters, scintillometers, and other instruments.

Applied terrestrial Remote Sensing involves the detecting and measuring of electromagnetic energy (usually photons) emanating from distant objects made of various materials, so that the user can identify and categorise these objects by class or type, substance, and spatial distribution. Generally, this more conventional description of remote sensing has a specific criterion by which its products point to this specific use of the term: images much like photos are a main output of the sensed surfaces of the objects of interest. However, the data often can also be shown as "maps" and to a lesser extent "graphs", and in this regard are like the common data displays resulting from geophysical remote sensing. As applied to meteorological remote sensing, both images (e.g., clouds) and maps (e.g., temperature variations) can result; atmospheric studies (especially of the gases in the air, and their properties) can be claimed by both traditionalists and geophysicists.

Still, space systems - mostly on satellites - have made enormous contributions to regional and global geophysical surveys. This is because it is very difficult and costly to conduct ground and aerial surveys over large areas and then to co-ordinate the individual surveys by joining them together. To obtain coherent gravity and magnetic data sets on a world scale, operating from the global perspective afforded by orbiting satellites is the only reasonable alternate way to provide total coverage. All of these statements are valid and, taken together, should give you a reasonable insight into the meaning and use of the term "Remote Sensing" but its precise meaning depends on the context in which it is spoken of. Thus, some technical purists arbitrarily stretch the scope or sphere of remote sensing to include other measurements of physical properties from sources "at a distance" that are more properly included in the general term "geophysics". This would take in such geophysical methods as seismic, magnetic, gravitational, acoustical, and nuclear decay radiation surveys. Magnetic and gravitational measurements respond to variations in field forces, so these can be carried out from satellites. Remote sensing, as defined in this context, would be a subset within the branch of science known as Geophysics. However, practitioners of remote sensing, in its narrower meaning, tend to exclude these other areas of geophysics from their understanding of the meaning implicit in the term Hartmann, 1996a, 1997c, Hartmann et al. 1996a,b).

Images as an example of Remote sensing

Images provide one of the most important ways we have of understanding the world around us. Our eyes supply us with an almost continuous stream of full-color images with non-stop action. But there is an infinite number of images of the world we cannot see directly because of the limited sensitivity of our eyes and the difficulty of leaving our normal environment on the surface of Earth. So we build instruments that can detect what ours eyes cannot and send them to places that are hard to reach, and program them to return the images they detect back to us. The art and science of gathering and interpreting those images and other information about objects from a distance is called remote sensing. Remotely sensed images recorded by instruments aboard aircrafts, manned spacecrafts, and satellites already provide us with many different types of information about our Earth. The montage of images on this page shows a sampling of different remotely sensed images centered on New York City on the East Coast of North America. Perhaps the most familiar type of remotely sensed image is the GOES weather satellite image. In order of increasing detail or resolution, there is also a visible-light

DMSP night view of the lights of New York and nearby cities, a Landsat mosaic of the New York region, an NDVI image of the New York region, a color photograph of New York City taken from the space shuttle, and a SIR-C radar image of downtown New York City also taken from the space shuttle.

4.3 From Data Acquisition to (value added) validation

Figures 3a, b, c, 4, 4a, and tables 3, 4, 5)

Data Acquisition

The basic meaning data acquisition means "Reliable technical recording of raw data". This inevitably includes **consistency checks**. At this stage we deal with just the outputs of the measuring equipments which might be given in voltages, counts etc. and which are neither calibrated nor somehow related to the interesting physical quantity. (It is of no use to make them accessible in public information systems!)

Reliably calibrated, deconvolved data and their accuracy

Calibration. It must be emphasised how important and often difficult a reliable calibration is. The often-used term "calibration" has different meaning for different types of measurements as will be shown in the following:

a) Amplitude or intensity measurements are calibrated in the original sense, i.e. by switching the instrument between the measurement target and a well known stable reference source/oscillator.
b) Frequency response of a given instrument must be checked with standard frequencies.
c) Since electronic equipment can measure phases only modulo 2π, a calibration here means the removal of the 2π ambiguity.
d) Time delay measurements are calibrated against a very stable reference clock.

Calibrated (raw) data with error bars should be stored in data centres, when it is intended to perform there also value added validation.

In this context we have also to distinguish between **precision** and **accuracy** of a measurement. The first is also denoted as the relative error/uncertainty and the second one the absolute error/uncertainty which also includes the systematic error. To determine the latter we need at least two experiments that are based upon different physical principles. (Hartmann, 1993b. 1997c, 1998).

Verification

Since our modern empirical science is essentially based upon the idea of verifying ("see yourself") somebody else's measurements we need to discuss this aspect briefly.

Verification means to perform measurements independently with identical equipment, based upon the same physical and technical principles, to calibrate and evaluate them using the same references and assumptions, and finally to compare the two results. The cross-correlation between the two independently obtained sets of data is a measure of verification, the standard of which must be determined **intersubjectively** by the community If the data set is unique or it is the only one till now available then the experimentalists should supply to other interested, experienced colleagues upon request all information about the system, its calibration, the data set and the assumptions and algorithms used for the data evaluation in order to allow independent evaluation. The present data fraud scandals make this quite clear. Since identical equipments have been used for verification measurements, inherent systematic/bias errors cannot be revealed.

Validation

Systematic errors may be indicated if the data from measurements of the same physical quantity based on independent or different physical principles are compared. This comparison is validation. The degree of agreement among these data sets, whether below or above the standard set by the community determines intersubjectively the worth of the data set.

Validation requires a scientific process which has three interrelated features:

1. It is not pure reason, but rationally built with creative power on validated experimental data.
2. It continously updates or renews the results through self-consistency checks.
3. It takes place – intersubjectively - in the respective science community.

a)Doing an experiment is an act of faith. There is no guarantee for success, now matter how thorough is the preparation. The more profound a theory, the harder the experiment and the longer it takes. Of course one can always choose not to do the experiment.

b) All data must be interpreted, a process never free from prevailing theoretical understandings and expectations at the time. The subjective influence in the interpretation of data, however, can be minimised or removed by a commitment to logical self-consistency and universality. The verification and validation of data and self-consistency checks are done in the context of the respective (scientific) community which sets the validation margins and which has a life bigger and longer than the individual member.

At present in our nation states validation and self-consistency checks of data and their (interactive) linkage with relevant texts (literature) are the more insufficiently recognised the larger the speed of change and the information growth rates get. The need for qualifying filtering and validation of data – together with a user-friendly linkage of texts - however, increase because of the fact that as the quality of data decreases the legal, economic, ecological, and scientific-technical risks incurred in using them increase. The optimal validation is possible with the so called “joint retrieval” using calibrated raw data from different experiments together with “assimilated” model data in a joint algorithm. The advent of the new generation of high data rate environmental observation satellites - e.g. ENVISAT launched in March 2002 - increases the annual data growth rate from about 10% to about 50%. This is a hitherto insufficiently recognised challenge for the relevant qualifying filtering and validation activities. It has been reflected in the concept of the DUST-2 CD pilot project: DUST-2: An interactive graphic linkage of texts and data, applied to ozone and water vapour and other selected data of the Earth’s atmosphere. (DUST: Data Utilisation Software Tools). See also chapter 6.

Value added validation

Data from remote sensing measurements are generally described with integral equations which contain the interesting parameter within the integral. In order to obtain these parameters the integral equation needs to be “inverted”. Special mathematical tools (inversion algorithms), powerful computers, some “apriori knowledge” and the just mentioned measured data are required. The measured data will have an unavoidable finite “error” and in the case of remote sensing data they should be verified and validated. The smaller the unavoidable uncertainty the smaller will be the “error” of the solution of the integral equation. For non linear error propagation - “chaos situations” - a small uncertainty in the measured data can lead to a large error in the solution of the integral equation. Only in the case of pure mathematics the (measurement) error is negligible so that a solution of the integral equation that has only a small difference to the apriori can be considered a more realistic “picture” of our environment. In the other case the solution might be just called a confirmation of the “apriori knowledge” (Input =Output!).

A thoroughful (extensive) validation of large amounts remote sensing data e.g. from the atmosphere needs the existence of relevant user-friendly data centres, which can support the scientists - even more so non-experts - especially in intercomparing large amounts of data from various sources.
The very important role of data centres for non experts for online-, off line storage and retrieval tasks will be not further considered here, also not the services that are required for experts and non experts visiting the data centres in order to work there. This will become more important the more the amount of data increases, e.g. from various remote sensing experiments and in situ experiments as well as from computer model calculations.
If a compressed data product of still higher quality is required then it can be calculated, e.g. through a **„combined optimal retrieval“ (COR)** from two or more different „co-located and co-timed“ data sets (calibrated raw data) - eventually also „model assisted“, in other words using the **„assimilation approach“**. The author denotes this process **“optimal value added validation“**. Especially here the support of the data centres is needed the more the more the data flow increases, which will occur with the advent of the next generation of satellites like ENVISAT. An optimal value added validation possibility is described in chapter 7.2 “The MAS/GRAS sensor combination for the ISS“.

Data presentation and compression

Mankind exists in four-dimensional world that depends on three space coordinates and one time coordinate. Human perception (intuitive knowledge, vision) restricts us in general to three dimensions, i.e. our understanding of graphic presentations refers at maximum to three variables. However, in most cases this is insufficient when, for example environmental parameters are to be described. If Λ is the geographic longitude, ϕ the geographic latitude, h the altitude above or under the surface of the Earth, and t the time, all the observed environmental effects (measured data) are more or less dependent on all four parameters. Therefore, $F=F(\Lambda,\phi, h, t)$.
Four steps for data compression have to be mentioned: a) graphic presentation, b) statistical analysis, c) modelling and parameterisation, d) special filtering, e.g. with the wavelet transform or other qualifying filter methods.
Here only graphic presentation has been more detailed considered. It has become increasingly important because of the new graphic communication systems (e. g: PCs, with graphic display and multi media devices). To display the above mentioned F, a five-dimensional presentation (four independent variables and the value of the function F is needed). If the cathode ray tube (CRT), which itself is two-dimensional, is utilised for displaying F, the following three possibilities are obtained.

1. Graphic display (still picture) of F as a function of *one* variable, i.e. an actual two-dimensional presentation. This is the well-known, widely used classical display method.
2. Graphic display (still picture) of F as a function of *two* variables, i.e. a three-dimensional presentation on a two-dimensional screen. This is the main subject of computer graphics. (Using (three dimensional) holography techniques, an actual three-dimensional presentation is possible).
3. Graphic display (moving picture) of F as a function of *three* variables, i.e. a three-dimensional presentation *plus* time scale on a two-dimensional screen. (Using holography techniques, "moving" three-dimensional presentation is possible). Application of additional video and/or regular film techniques will expand the presentation by adding color, sound, and fast-motion effects, and others. (Multi media.)

The **wavelet transform**: The characteristics of the Fourier transform (FT), the Gabor Transform, a Short Term Fourier Transform (STFT), and the wavelet transform are compared. The wavelet time frequency window narrows for large center frequencies and widens for small center frequencies. This „zoom lens“ characteristics is most desirable in time frequency

analysis and it is also denoted as a filter with constant Q. Wavelet transforms are very often used for data compression tasks and multiresolution analysis. (Hartmann, 1997b).
If a compressed data product of still higher quality is required then it can be calculated, e.g. through a „**c**ombined **o**ptimal **r**etrieval" (COR) – fig. 3 – from two or more different „co-located and co-timed" data sets (calibrated raw data) - eventually also „model assisted", in other words using the „assimilation approach". The author denotes this process **"optimal value added validation"**. Especially here the support of the data centres is needed, the more the more the data flow strongly increases, which has been started with the launch of ENVISAT - launched on March 1st , 2002. It belongs to the next generation of satellites.
As already mentioned the inevitable subsequent step - the more the larger the amount of data - is an increased qualified filtering process an example of which is described in more detail in chapter 6, the DUST-2/ADLATUS concept.

5. Data growth rate problems

As an unspecialized curiosity being man needs information for his survival. This is especially true for the biosphere and the three geospheres, atmosphere, hydrosphere/cryosphere, and lithosphere/pedosphere. Since several decades in the industrialized nations one experiences in many domains of the geo-sciences, e.g. in atmospheric research, but also in many other domains, that there is an increasing surplus of primary information accompanied by an increasing shortness/lack of secondary information. **Primary information** comprises all raw data from measurements and the knowledge that guides the ability of producing and which Aristoteles denoted "Techné". **Secondary information** comprises all qualified selected data and their interpretation as well as the knowledge that guides the practice and which Aristoteles denoted "Phronesis" (Reasonability). In the last years the tension between these two poles has reached a magnitude that we must consider it as a serious information crisis. The colloquial terminology uses the expression „information explosion" or information inundation.
Information is "created" by a filtering process, i.e. is time dependent. Information contains preliminary certainties which are made prominent against the determinable uncertainty. Information is "created" in the complex of NOUS-GNOSIS-PHYSIS-MYSTERIUM that relates the person who cognizes (NOUS) and the cognition process (GNOSIS) to the appearances (PHYSIS) and the unknown, hidden (MYSTERIUM), see fig. 7.

More than 160 definitions for information exist today. This leads not only to confusion but contributes also to the present growing information crisis. Information is „created" by a filtering process i.e. is time dependent. This yields to a new description: **„information contains (preliminary) certainties which are made prominent against the (determinable) uncertainty".** In analogy to radio science, the determinable uncertainty: the noise, is as important as the preliminary certainty: the signal. How much the signal is pronounced with respect to the noise is determined by at least two time periods.
It is estimated that the human beings produce per annum about 10^{18} bit information. The physical limits for the production of bit in the system Sun-Earth-Interplanetary Space is still 25 orders of magnitudes larger (10^{43} bit), i.e. these limits are very far away. This, however, is not true for the biological/capabilities of the human beings, that determine their limits of information processing (storage, retrieval, and interpretation). At present we approach very fast these limits especially in the highly industrialised nations. The fast progress in microelectronics and in computer engineering supported the drastic increase of information, since there were only small barriers for electronic processing and storage. In the meantime it became clear that there originated new, hitherto unknown problems, for the users who want to master the information inundation. From a different point of view this is also true for the

institutions that deal with data, e.g. administrate data, regardless whether we deal only with bibliographic data or with numeric data or with alphanumeric data, a mixture between the two. The greatest progress exists in the domain of bibliographic data. There is only little progress in the domain where we deal with large amounts of numeric data, especially those that have time series character. The fast technological changes and progress lead also to the fact that it gets increasingly complicated to process older data. In many cases it is already impossible. This led to the term *„technical forgetting"*.
Today about 90 % of the electronic data processing costs are software costs and only about 10 % of the costs are hardware investment costs. Twenty years ago this was just opposite. During the last five years **the hardware - software gap has been transformed into a software crisis.**
Since two decades the large progress in microelectronics and computer technology provided the basis for the new **multi media**. The very dominant "video-communication" begins now to lead to the following statement << Video, ergo est >> (See it, therefore it is). What a change from a statement by Descartes (1596 - 1650) << Cogito, ergo sum >> (I think, therefore I am)
The new media inundate us with global, regional and local information. This may lead to information refusal or depression - deformation - as some psychologists claim, or to a much broader and wider view of the world and to more democracy, responsibility and participation in the decision making processes, however, by „indirect" experience through thinking, i.e. without direct feeling. Thus the new media contribute in general to an increasing separation of body and mind in a sense of Platonism. This is opposite to another trend for integrating (better: for a synergetic combination) mind, body, and soul.
Since nowadays the information processing capabilities of computer, transputer etc. are much better known than those of human beings, who have to interface with the computers, the human information processing capabilities will briefly be mentioned. The influx of sensory information for a human being is about 5×10^7 bit s^{-1} for optical and about 4×10^4 bit s^{-1} for acoustic information. The so-called channel capacity of technical transmission systems is matched to the sensory systems. (Television channel ≡ 7×10^7 bit s^{-1}; telephone channel ≡ 5×10^4 bit s^{-1}.) For reading and for listening of meaningful phrases, a maximum information flow of about 45 bit s^{-1} was measured, an excellent pianist "creates" 23 bit s^{-1} and simple counting out yields 3 bit s^{-1}. Despite the fact that only larger, partial aspects of human central nervous system, i.e. about its information processing, are known, we know that the roughly 10^{12} neurons perform in the sensory part an information reduction from about 10^7 bit s^{-1} to 10 bit s^{-1}, i.e. by a factor of 10^6. This is necessary in order to reduce the larger sensory information flow such that a further processing and storage is possible. A continuous information flow of 10^7 bit s^{-1} over 30 years would require a storage capacity of 10^{16} bit. This is more than 10^{12} neurons can handle.
If the flow of 10^7 bit s^{-1} is reduced by a factor of 10^6 the required storage for a continuous flow over 30 years would require a capacity of 10^{10} bit. However, this is reduced by a further factor of 10 because only 10% of the "reduced information" is stored in the long-term memory of a human brain.
The genetic code of man has stored an information of 10^{10} bit. For comparison the capacity of some technical storage devices are now given: Optical disk: 10^{12} bit; record: 10^9 bit; micro chip: 10^6 bit; printed (DIN A4) page: 10^4 bit
In principle these considerations are useless, except if we start to think about how this huge information flux is dealt with in our brain such that the following is generated which is specific for human beings: Words, terms, categories - constant over long time periods - as well as pattern recognition. Today we distinguish four types of memory:
1. The autobiographic (episodic) memory
2. The fact and knowledge memory
3. The procedural memory - for learned motions etc.

4. The priming memory - narrow context experience

It is understood that these four types of memory are partly interrelated and not completely independent. (Hartmann, 1984, 1985, 1993a, 1996b, 2000)

6. The DUST-2/ADLATUS concept

6.1 The DUST-2 CD ROM: Background and steps towards an ADLATUS interface atmosphere and planning of an ADLATUS interface drinking water.

See: G. K. Hartmann et al., (2000) and DUST-2 publications (2000a-j).
The exponential growth of geophysical information must lead inevitably to a better access to geophysical information for science and education, especially if the resources shrink and the cost-efficiency ratio needs to be improved. That a better access means essentially more than just faster and more information is demonstrated by the **DUST-2 CD-ROM** (Data Utilization Software Tools). As a result of an international MPAe research project (FKZ.: 50 EE 98038) this CD-ROM has been published in September 2000 under ISBN 3-936586-02-0. It was conceived predominantly for scientific technical purposes and can be regarded as a continuation of the work which was started in 1985 at MPAe to edit a Landolt-Börnstein data handbook „The Upper Atmosphere". The DUST-2 CD is an example for an **interactive, flexible interface,** although a first step – matching several different non uniformly formatted data sources. The DUST-2 provides graphical methods of qualified information retrieval. It provides a synergetic combination of selected information of the Earth's atmosphere, texts and relevant numerical data for the topics ozone and water vapour. The software tools can be applied in principle to any data base.
The „joint retrieval method" allows an optimal, value added, data validation. This is demonstrated with a combination of temperature data from the Millimeter-wave Atmospheric Sounder (MAS) with corresponding ones from a GRAS sensor (GRAS: Combined GPS-GLONASS receiver) – see next chapter. The (dynamic) DUST-2 concept will contribute – from a qualitative and temporal aspect – to a reduction of the insufficient supply of (general, actual) understandable geophysical information. The **ADLATUS** concept – still in the planning and fundraising phase – supplements the DUST –2 concept and puts special emphasis on educational aspects. The concept was successfully presented as poster at the EGS (European Geophysical Society) General Assembly in Nice – France - in April, 2000 , which is stored on the DUST-2 CD.
The expected strong increase of atmospheric data e.g. by ESA's ENVISAT (Environmental Satellite launched on March 1st, 2002) will be a great challenge for all relevant data base systems. These data are important for studies on climatic changes. Ozone data are especially essential because of the influence of the UV radiation on the biosphere including humans. Graphical tools providing an obvious and intuitive interface to the data, both numerical and textual get increasingly important for data bases, proportional to the magnitude of the data flux. They assist in exploring, selecting from, and searching the database. They have been combined and investigated in context with a pilot project for the validation of atmospheric data, carried out at the Max-Planck-Institut fuer Aeronomie (MPAe) in Katlenburg-Lindau, Germany and supported by DLR (Fkz. 50 EE 98038 from 01.01.1998 – 31.08.2000).
The concept of DUST-2 is not restricted to an application in geophysics. It can also be applied to other (very large) scientific-technical data bases, e.g. other time series data from biology, medicine or economy. It will allow to improve simultaneously information width and information depth, in striving to apply (non linear) zoom-like filters, e.g. as realised with the "wavelet transform". Optimal information width is equivalent with an optimal coverage

(completeness) of the relevant field, optimal information depth with the possibility to be able to optimally retrieve also the details.
With DUST-2, classical and modern documentation methods – comprising data classification, storage and retrieval – and validation methods for selected data and texts of the earth‘s atmosphere can be interactively graphically linked and the results displayed. The software functionality includes visualisations, animation and mathematical statistical processing and allows to reveal ozone trends or to ascertain differences between data sets. It should help to improve the present insufficient availability of qualified filtered, direct useably information. It should further initiate and support related learning processes. Further information is available at: http://www.science-softCon.de

6.2 The DUST software

The satellite data product specification requested by scientists, public authorities, schools, commercial users, or the media possess a range of variation as large as the spread in the user groups themselves. However, data centers concentrate on the operational generation of only a few selected data products, since their processing is elaborate and complex.
This provided the motivation to develop easy-to-use software which takes into account user specifications collected over a long period of time.
The DUST software focuses on providing software for processing and visualization of selected **level 3 atmospheric** data from the GOME, TOMS and MAS instruments.
This software is based on the public domain DUST-1 software package which was developed on behalf of the German Remote Sensing Data Center (DFD) in 1999 (Nölle et al., 1999).
In addition to the DUST-1 selection tools (species, sensors, and calendar), the DUST 2 software contains the new search tool (S^4) for spatial and temporal search and an HTML-interface to the TOSCANA software (Kollewe et al., 2000). This enables a more selective data search and the combination between alphanumerical data (texts) and numerical data (measurements).The software functionality includes visualization, animation, and mathematical/statistical processing of the data sets.
The DUST-2 (Data Utilization software Tools) software is a possibility in visualizing and processing ozone and water vapor data of the Earth atmosphere as measured by satellite instruments (TOMS, GOME, MAS) and provided by different data centers. Some examples from the DUST-2 follow: MAS (H_2O), TOMS (O_3) and two animations from the UV-B index from Europe and the World.
In addition, a new search tool (S^4 tool) which allows to search for comparable ozone and water vapor data in four dimensions (location and time) within the DUST-2 data base and a hdf2csv tool are represented, the latter allows the conversion of the hdf formatted GOME data at DFD into the easy to handle csv format. The software package as well as complementary information and data examples are published on CD-ROM (“Data Utilization Software Tools – 2”, DUST-2, Hartmann et al. 2000) under ISBN 3-936586-02-0 which is available via www.copernicus.org or via www.science-softCon.de (Dr. A. Noelle).

6.3 e-publishing/digital publishing

In order to reduce the so called “digital divide” between the highly industrialised nations and the non highly industrialised nations in addition to the ADLATUS interface concept e-publishing has been introduced. The term **“digital divide”** stands for the fact that the fast progress in IT technology and the accompanied data growth rates lead to the fact that The well informed (highly industrialised nations) have the means to get continuously better informed – if they meet less insufficiently the data growth rate problems - and the poorly

informed (non industrialised nations) get – mainly because of a lack of financial and human resources - increasingly poorer informed.
The concept of e-publishing according to the *Budapest Open Access Initiativ (BOAI)* – see chapter 11.4 - provides for the non industrialised nations not only faster and more economic access to international scientific information – probably a third of the present costs for accessing the "classical media"- but also allows to make faster and more economic their own qualified contributions available to the international scientific community. The international (non governmental) science organisations will play here a major role.
The more and faster the Open Access Activities will grow the more the problem of less inefficient qualifying information filtering must be addressed. This has been a major aspect in the DUST-2 CD pilot project (Hartmann et al., 2000). Of specical interest are there the description of the following new methods:

1) SOMAccess "Interactive Text Retrieval Based on Document Similarities" (Klose et al., 2000) – emails: klose@iws.cs.uni-magdeburg.de , rudolf.kruse@cs.uni-magdeburg.de , anuernb@eecs.berkeley.edu , http://fuzzy.cs.uni-magdeburg.de/
2) Formal Concept Analysis (FCA) (Wolff et al., 2000) ; e-mail: Karl.Erich.Wolff@t-online.de) which has been combined with the TOSCANA software (Kollewe et al., 2000) , email: kollewe@navicon.de , http://www.navicon.de/

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- Archiving data and information for public usage
- Developing appropriate hard- and software for achieving these aims

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Phone: +49-5556-91099; Email:info@copernicus.org ; URL: http://www.copernicus.org

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1. Budapest Open Access Initiative (BOAI, http://www.soros.org/openaccess/)
2. Scholarly Publishing and Academic Resource Coalition (SPARC and SPARC Europe – http://.sparceurope.org/)
3. ROQUADE (http://www.roquade.nl)
4. Signal Hill (http://www.signal-hill.org/)

See also appendix 11.4

Example of e-publishing in: Atmospheric Chemistry and Physics Discussions (ACPD)
The author of this lecture (G. K. Hartmann) participates as co-author on the following paper - http://www.copernicus.org/EGS/acp/acpd/2/507/acpd-2-507.htm Observations of large stratospheric ozone variations over Mendoza, Argentina, C. Puliafito, S. Enrique Puliafito, and G. K. Hartmann, Atmos. Chem. Phys. Discuss., 2, 507-523, 2002. See also: http://www.copernicus.org/EGS/acp/index.htm

7. The MAS/GRAS sensor combination proposed to be flown on the International Space Station (ISS)

7.1 The Millimeter Wave Atmospheric Sounder (MAS): An example of Space Research from the NASA Space Shuttle

(Hartmann et al. 1996a, 1997b)

Introduction

Although active microwave systems, i.e., radar, are the more commonly used sensors for this region of the spectrum, passive microwave sensors also have provided information about the Earth's surface, its oceans, and its atmosphere. Air- and space-borne sensors have operated for several decades. They measure directly radiation incited by thermal states in these media and hence are representative of natural phenomena inherent to the materials (hence, passive). The principle underlying passive microwave radiation is implicit in the following spectral curves that show relative intensities of radiation (radiances) as a function of wavelength for materials with different intrinsic temperatures.
The Millimeter-wave Atmospheric Sounder (MAS) a remote sensing experiment has been successfully flown with three NASA Space shuttle missions. G. K. Hartmann has been the Principal Investigator (PI) of the **M**illimeter Wave **A**tmospheric **S**ounder (**MAS**) experiment, which as a joint enterprise of Germany, Switzerland, and the USA and has been flown as core payload of the NASA ATLAS (Atmospheric Laboratory for Applications and Science) Space Shuttle Missions (ATLAS-1 (1992), ATLAS-2 (1993), ATLAS-3 (1994); Millimeter-wave radiation emitted by the atmosphere in the height range between 10 km and 100 km has been measured at 61, 62, 63, 183, 184, and 204 GHz. MAS yields information about the altitude profile of temperature (T), and pressure (P) as well as for water vapour, ozone, and chlorine monoxide in the stratosphere, and mesosphere, in the latitude range between 72 degree northern and southern latitude for an orbit inclination of the Shuttle of 57 degrees. Chlorine monoxide plays the major role in the catalytic, anthropogenic ozone destruction in the stratosphere. The MLS experiment – similar to MAS – however, on the UARS satellite, and MAS were the first that could measure chlorine monoxide globally from space and thus contributed very essentially to the investigation of the polar stratospheric ozone holes. Now the water vapour results reach almost equal importance.

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NIWA (National Institut of Water & Atmospheric Research Ltd. Lauder, New Zealand) Connor, B.
UM (University of Mendozza / CONICET, Argentinien): Puliafito, E.
For **more information** see: . http://www.linmpi.mpg.de/english/projekte/mas/ .

MAS „Highlights“
The recent MAS results have been published in seven papers in the Geophysical Research letters, vol. 23, number 17, 1996 and in the Proceedings of the Quadrennial Ozone Symposium, Sept. 12-21, 1996 (D. G. Feist et al. "Comparison of MAS stratospheric ClO measurements with spaceborne, airborne and ground based measurements).
Complementary to the absorption experiments which need the sun as the radiation source and which can only measure during daylight the emission measurements as carried out by MAS can measure also during the night.
Using the high resolution 200 kHz spectrometer channels from MAS - they have a factor of ten higher resolution than any other microwave spectrometer from space - it was possible for the **first time** to measure the day-night variations of ozone (O_3) water vapour (H_2O) and oxygen (O_2) in the mesosphere and lower thermosphere as a function of geographic latitude. For example in 55 degrees southern latitude there has been observed a strong increase of the night-time ozone - up to 8 ppmV (part per million volume mixing ratio) in 92 km altitude. As a possible mechanism the following process is considered : $O + O_2 + M \rightarrow O_3 + M$ (M: collision partner). The day-night difference allows an estimate of the daytime atomic oxygen. The evaluation of the Zeeman effect of the 9^+ oxygen line - it was measured for the **first time** by MAS - allows an estimate of the O_2 density and already without inversion calculations an estimate of the temperature of the mesosphere in about 80 km altitude.

The main goal of MAS, however was not to contribute to the basic research of the mesosphere but to investigate the anthropogenic ozone destruction in the stratosphere, especially that portion which is caused by ClO. MAS is besides MLS on UARS the **only** instrument that can measure ClO from space. The comparison of ClO data from MLS and MAS showed not only the expected agreement but furthermore that MAS data played a very important role in the MLS-ClO validation procedure.
The further planned, but because of funding problems cancelled, seven further ATLAS missions would have provided a very flexible calibration and validation possibility between the end of the MLS ClO measurements and the new planned satellites.

7.2 The MAS/GRAS sensor combination for the ISS

A realistic simulation study investigating joint retrieval based on both MAS data and GRAS (GPS/GLONASS Receiver for Atmospheric Sounding) radio occultation data has been performed by MPAe, IGAM (Graz) and IFe (Bremen). It showed that this allows to achieve very favourable accuracy of temperature profiles of the Earth's atmosphere, i.e. this method – combined with a so called assimilation of model based data - presents hitherto the most efficient data validation. Thus a combination of a MAS/GRAS Follow-on experiment – i.e., a modified MAS with second generation radiometers, electronics, and a star sensor – together with a GRAS receiver on the **EXPRESS Pallet** of the **International Space Station (ISS)** is highly recommended. This would allow to obtain not only more accurate temperature and water vapour profiles but also provide simultaneously liquid water data below 17 km. All these quantities are very important for climatological research. A technical feasibility study showed that the proposal was realistic. For more details see: fig. 6 and report Hartmann et al. (1997). A MAS H_2O measurement is displayed with DUST-2 see: MAS

MAS/GRAS Follow-on can supply for the first time the possibility to measure from space simultaneously in the tropopause region water vapor and liquid water data - through a unique combination of MAS with a GPS/GLONAS (GRAS) receiver and a star sensor - that are especially important for climatological research in the equatorial region. In a 6 to 12 months matched experimental (pre-operational) phase, e.g. very important data about the El Nino phenomenon can be obtained. Furthermore the adaptation of MAS to the conditions of the ISS will also allow to introduce and test new technologies, and to create - under the difficult ISS conditions - the possibilities for future autonomous, operational (small or dedicated) faster and cheaper satellite instruments for the Earth observations. The MAS/GRAS data should be verified and validated with relevant (e.g. microwave) ground based measurements, and complemented by measurements from large satellites like ENVISAT and others as well as those from aircrafts, balloons, rockets, and dedicated small satellites.

In the year 2000 a **Combined Optimal Estimation Retrieval for the MAS/GRAS Sensor data** has been done by part of the international MAS science team consisting of:

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Table 1. Measured quantities by combining MAS Follow-on (M) with GRAS (G):

Quantity	MAS frequency	Height Range [km]
Temperature	61 GHz	0–50 (G) + 15–90 (M) = 0 – 90
Pressure	62 GHz	0–50 (G) + 15–90 (M) = 0 – 90
H_2O	180 GHz	< 7 km (G) + > 7 km (M)

H_2O	183 GHz	17 – 95 (M)
O_3	184 GHz	17 – 95 (M)
ClO	204 GHz	17 – 45 (M)

MAS/GRAS combined retrieval results

We investigated, with the aid of the optimal estimation method, the retrieval accuracy of temperature profiles from MAS-only and GRAS-only data analysis and, of particular interest, from combined MAS/GRAS data analysis. The retrieval accuracy of water vapour profiles from GRAS data analysis was studied as well.

MAS and GRAS sensor data were simulated based on a realistic sounding geometry assuming the sensors mounted on an ISS EXPRESS Pallet and probing the same air volumes toward the backward limb. A representative sample of 30 globally distributed GRAS occultation events and co-located MAS limb sounding scans were "forward-modelled" using enhanced versions of the MSIS-90/CIRA-86 models. Retrievals were then performed on a case-by-case basis and retrieval error statistics were produced.

For temperature we found a modern MAS/GRAS sensor to achieve < 1 K accuracy below 35 km at ~ 1 km resolution and < 4 K accuracy throughout the mesosphere at ~ 5 km resolution. Water vapour can be retrieved from GRAS data to < 10–20% accuracy below 5 – 8 km, assumed a priori water vapour uncertainty: 25%).

The need for joint H_2O retrievals

Water is the only substance that occurs not only in all three phases, gaseous, fluid, and solid in the Earth's atmosphere but also in transitions between them like in its "polymer forms" - clusters, clathrates, aerosols. Although the importance of the solid and fluid forms is popularly understood, there is less general understanding of the role of water vapour and especially for its polymer forms than for example, of carbon dioxide (CO_2) or ozone (O_3). The spatial and temporal distributions of the various phases of water in the atmosphere are in fact very important factors to climate, weather, the biosphere, the homogeneous and inhomogeneous chemistry of the atmosphere, as well as to the propagation of electromagnetic waves used in transatmospheric (global) navigation and communication systems and for relevant remote sensing measurements. In this context the atmosphere acts like a temporal and spatial variable, frequency dependent filter. Despite the fact that above the tropopause, i.e. in the stratosphere and mesosphere, there is less than 0.1 % of the total water vapour content of the Earth's atmosphere its influence is very significant for the physics and chemistry of the upper atmosphere and hence for the climate.

It has been recently shown that the accuracy of radiosonde (H_2O) humidity measurements, e.g. with Vaisala Humicap humidity sensors, strongly suffers from aging – outgasing – effects. The suppliers of these sondes now try to remove this effect at a reasonable costs. This however, implies, that until now these humidity data can only insufficiently or not be used for (longer term) climatological trend research, i.e. for the "calibration" of relevant H_2O remote sensing measurements. Because of these problems the opposite right now occurs, namely the calibration of radiosondes humidity measurements with microwave remote sensing data. It was also recently shown by A. Gasiewski (NOAA ETL, Boulder, CO., USA) in a private communication that the calibration of the present DMSP H_2O radiances is hitherto insufficient for the investigations of small trends, i.e. for climatological research or relevant "calibrations". At MPAE this terminated the attempts of a value added validation of the MAS H_2O data. This was also much influenced by the fact that there has been insufficient co-

location and co-time for such validation (verification) work with relevant UARS MLS H_2O data, mainly because of the large temporal and spatial variablitiy of the water vapour distribution in the Earth atmosphere.
These new findings direct now the attention to the use of GPS H_2O data which predominantly yield columnar (integrated) water content, i.e. precipitable water. Furthermore it fosters co-located and co-timed multi spectral measurementes of the atmosphere in the millimeter and submillimeter range together with "hyperspectral" optical imagers from the ground, aircrafts, balloons, and from space. Very interesting in this context is the "Peacewing" proposal of A. Gasiewski, for which he asks for further participants. All these multispectral measurements will allow in the most cases joint retrieval calculations for various H_2O data. They will provide especially H_2O height profiles in a similar manner as shown in chapter 3 for the MAS/GRAS temperature profiles. While the MAS measurements are based upon the information that is contained in the imaginary part of the refractive index of the Earth's atmosphere, GRAS uses complementary to it its real part. Therefore the information gain for the joint MAS/GRAS temperature retrieval is optimal high. If an height overlap can be obtained also for the H_2O MAS/GRAS measurements – theoretically by using also 20 GHz measuring channels – then the same can be expected for a joint H_2O retrieval. It should be noted that the MAS Follow-on measurements would also provide simultaneously liquid water profiles below 17 km. All these quantities are very important for climatological research.
(Hartmann and Oberländer, 1977, Hartmann, 1993b, and 2000j.)

7.3 Conclusions for the MAS/GRAS sensor combination on ISS

It seems highly worthwhile to place a MAS/GRAS Follow-on sensor on the EXPRESS Pallet of the International Space Station (ISS). In fact it were a role model of synergistic use of sensors in the best sense. It is an example of an optimal (value added) validation. Therefore a MAS/GRAS feasibility study or a phase A study can be highly recommended, especially for non highly industrialised nations that want to participate in and significantly contribute to actual space research and relevant high tech hardware and software technologies.
Hartmann et al. 1997, 2000d)

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10. The author

Gerd Karlheinz Hartmann (Dr., Prof.), born in 1937 in Eschwege, Germany, studied physics from 1957 to 1964 at the Georg-August-University in Göttingen, where he received his PhD. in 1967. Since 1965 he is married with Marianne Hartmann, (Panke).

Since 1965 he has worked as a scientist at the Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau. For over ten years he concentrated his activities on studying the upper atmosphere using satellite (radio) beacon signals.

Since 1967 he has been dealing also with general and specialised information and documentation problems, from the viewpoint of large volumes of time dependent and space dependent data, especially of the type collected in his research projects. At present he works as a consultant on several national and international committees and holds lectures and seminars throughout Europe, and especially in the USA., in Argentina, and Chile, countries he has often visited in the course of his scientific projects.

From 1975 to 1978 he was the provisional director of a division of the institute, the Institute for Long-term Control of Geophysical Environmental Conditions (ILKGU).

Since 1979 his main area of specialisation has been studying the lower atmosphere by means of microwave radiometry. He has been the Principal Investigator of the **M**illimeter Wave **A**tmospheric **S**ounder (MAS) experiment which as a joint enterprise of Germany, Switzerland, and the USA has been successfully flown as core payload of the NASA ATLAS Space Shuttle Missions (ATLAS-1 (1992), ATLAS-2 (1993), ATLAS-3 (1994); ATLAS: Atmospheric Laboratory for Applications and Science. For more information see: (http://www.linmpi.mpg.de/english/projekte/masnew).

Since 1980 he has been "consultant" for information problems of the Institute of Intercultural Co-operation/Intercultural Research" (ICC/IIR: Heidelberg/Zürich/Pernegg). In the 80ties he travelled on behalf of that institute to India and Asia, especially for discussing his concept of the (intercultural) information system OCIR/VIGRODOS. He participated in and contributed to international conferences on problems of intercultural understanding and cooperation.

1986 he became guest professor and guest lecturer for filter and information theory at the University of Mendoza, Argentina. This task was extended in 1988, now also including problems of conserving utilisation of the environment (sustainable development). In this context he is the international co-ordinator of the environmental program PRIDEMA started by the University of Mendoza (UM) in 1988.

1991 he became full professor at the engineering faculty of UM for "remote sensing for a conserving utilisation of the environment" (sustainable development) and also "external scientific director of the institute for environmental studies (IEMA) of UM. In December 1991 he received the Dr. Luis Federico Leloir Award for international co-operation with Argentina in the domain of environmental research from the Argentinean minister for Science and Technology, Prof. Dr. R.F. Matera.

Since 1995 he has worked on the "value added validation" of remote sensing data from the Earth's atmosphere resulting in the"DUST-2 CD ROM" and in the "MAS/GRAS follow-on proposal". He was the manager of an international experiment proposal for the investigation of the MARS atmosphere - in context with the MARS EXPRESS Mission of the European Space Agency (ESA) -, till it was cancelled because of funding problems in summer 1999.

Since 2001 he continues - as a pensioner - the DUST-2 activities, and the activities that have been started in Mendoza. See: http://www.sure-tec.com , and he works also as honorary consultant for science and technology for the German-Islamic Institute for Scientific and Cultural co-operation e.V., in Celle, Germany.

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11. Appendix

11.1 Science responsibility and risk management

(Hartmann, 1994, 1996d, 1997a, 1999, 2000).

(Empirically based) ***Science*** *contributes to a better way of seeing oneself in relation to the cosmos, complementary to the transcendence, enables technical and technological developments, and it is for the scientists a pretentious possibility of self-representation*

Since time immemorial Man has attempted in a vast variety of ways to predict spatial and/or temporal changes taking place in his physical environment so as to be better prepared to cope with the very serious risks they may involve for him. In the course of the last few decades, however, the nature, amount and mutual incompatibility of scientific prognoses with regard to "future prospects" have done a great deal to convince the "general public" of their essential unreliability. This has gone hand in hand, at least in the highly developed industrial countries, with constantly in creasing reliance in science and politics on expert opinion, that in many instances can only be described as slavish. The upshot of this is a crisis situation whose main feature is the drastically reduced credibility of science and politics in the public mind. The main reason is probably the mutually supportive influence of the following four "factors":

1. Our present views on the public nature of science and/or information.
2. The high growth rates of information (information explosion).
3. Increasing specialisation, particularly in the industrial countries.
4. Lack of competence (= expert knowledge plus a sense of personal identity) among many data users and indeed among many data producers.

The only way out of this crisis – in Chinese the symbol for crisis is composed of the two symbols for chance and risk - is to attempt to launch a number of counter-measures at one and the same time. Chief among these measures are :

a) Reduction of reliance on expert opinion.
b) improvement of expert opinion, particularly by an *increase of improved data* and *a decrease of bad data* (more quality than quantity).

What we mean by improved data here is that the "facts and figures" made available need to be supplemented by a *minimum of additional information* that at present is provided in only a tiny minority of cases. This minimum must include details on the nature and precision of the "measuring" and the assumptions that were necessary for their evaluation and/or interpretation. Only such critically "annotated" information can be properly slotted into the cultural environment, which can/must in its turn derive from its priorities for future data output. The more serious the economic and/or ecological situation is, the more urgent this requirement becomes. .

If we can prevent atomic or ABC warfare in the next few years, then it is probable that in 10-15 years time environmental policy will become the single most important global issue. In this fairly young area, in particular, we need an increase of improved data and a reduction of bad data. Given the high "reaction-time constant" of our present-day societies and the high time-constants of "environmental damage" and the "accumulation effect" , the repercussions of the glut of useless data and the expert reports based on them have so far gone more or less unnoticed. But these "effects"" are precisely what makes it essential right now to undertake steps to bring about a decisive improvement in the situation. Steps towards an improvement of data can certainly be taken within the framework of the hierarchic information systems prevalent in the West. The accompanying measures to curb the plethora of bad/useless information, however, require additional selection and/or qualification mechanisms for the so-called system input (of information into information systems). It has become apparent that

non-hierarchic information systems - which hardly exist as yet - can fulfil this task much better than their hierarchic counterparts.
At present in Germany more than 60 % of the state income stems from taxes that "labourers" pay. Since high-tech projects and big industry will not significantly reduce the present high unemployment level - may be rather increase it - a fast improvement of the governmental income is not in sight - even with the planned "Great tax-reform". It seems even more likely that the so called "globalisation trap" will further decrease the income of the national states. Since there is also now in the public a growing amount of rejection and hostility towards science and technology, not only science politics has to face a drastic change, but also science as a whole has to face further reductions in its "image" and in the funding from the governments. Since the global amount of money has not been reduced, other (private) funding sources for science and technology must be found. Several hundred years ago most of these activities were anyhow funded by private sources. Science politics and scientists must consider this more than hitherto. Science politics has to help to create more efficient, less bureaucratic ways to approach and use these sources, and scientists, (experts and non experts) and engineers have to "sell" correspondingly their "products". These products are the results from **basic science** and **applied science** often also denoted as the results from Research and Development (R&D) activities. Basic science increases the understanding of our environment and thus increases confidence into it - i.e. leads to a "**reduction of fear**" and it is the basic of tomorrow's applied research - i.e. an **investment for tomorrow**. Applied science is an important tool for the management of **today's risks and crisis**. Therefore applied science will dominate in the present crisis situations which is of interest to governmental as well as private institutions. However, we should always keep in mind, that this would not be possible without yesterdays basic research and that in the industrialised nations the future economic situation is strongly based on the research induced innovations.
Thus the dangerous mutual exclusive discussion of basic research and applied research must be stopped. We have to strive for a synergetic combination of the two in an "**in between**" structure where excellence for excellence's sake (Hartmann, 1996c) might be a new goal. In the in-between we will also have a reconciliation between the knowledge that gives tools for our disposal ("**disposal knowledge**") and the knowledge that brings order into our life ("**order knowledge**"). Thus science politics approaches culture politics the more we emphasize basic research; and it approaches the short-lived every day politics the more we emphasize applied research or research and development (**R&D**).
In periods of increasing economic crisis, artists and scientists encounter growing financial problems and it becomes increasingly difficult to pursue the goal of excellence for excellence's sake, despite the fact that this becomes more and more important for the society. (More quality than quantity). Artists and scientists have to defend the funding of art and/or basic science against applied science, technological activities. They have to try to replace at least parts of the no longer available public support by private sponsorship. The larger the economic crisis, the greater gets very likely also the hostility of the public against science, and the larger the bureaucracy of a nation, the more one needs "human catalysts", a synergetic combination of competent, motivated and responsible scientists, managers, and administrators, in other words public relations (**PR**) and interculturally experienced "**R&D catalysts**" for successful performance of research and development (R&D) projects. Whether or not this is realized by several cooperating team members, or can be realized in one person for example the principle investigator (**PI**) of a project, is less important.
This all implies that we should not only talk about the responsibility of science or scientists for risk and crisis management, but also about the responsibility of the individual citizen and the public for the science funding crisis. This talk is therefore intended to start discussions, dialogues and actions for both aspects, but only the first one will be treated in more detail here.

In our present free market dominated national states scientists and engineers have to "sell" their products to governmental and private institutions. The extent to which this needs to be done increases with the increasing global economic crisis, which probably due to the globalisation trend shows since about 10 years a feature that was unknown for more than 100 years and which now starts to prove that Karl Marx economic theory is right.(More than 10 years ago the capital profits and the wage increases showed a parallel trend, but now the capital profits strongly increase while the wage profits decrease together with a shrinking financial (tax) sovereignity of the national governments). This leads not only to a new and difficult situation for our democracies but also for the scientific community, especially for all R&D activities. The latter is amplified by the fact that there exists a principal problem when results and consequences of **special** R&D projects must be expressed in a **general** manner in todays colloquial, slogan loaded, language. This language is also based upon the collective consciousness (cultural background) from about 60 years ago. We also run into similar difficulties when we are asked to rationally explain possible future consequences of todays R&D actions. (The new tax policy that was introduced in New Zealand put recently this country into a very favourable situation compared to most other free market societies. If further globalisation might destabilize this needs to be seen)

Remark:

Results and consequences of research that occured less than 60 years ago have reached only to a very small extent the collective consciousness, caused by the principal time delay effect, and often only in slogan like terms that create additional ambiguities or make the communication process (dialogues) very time consuming and difficult. Thus if we want to reduce the time delay effect as much as possible we have to cultivate our language and sense for history such that this allows a faster and better mutual understanding. However, today we often observe the opposite, namely a decultivation of our languages, which makes the formal e.g. computer based exchange of complex information increasingly difficult and makes informal information exchange accordingly more important, especially if we also take the large growth rates of ("potential") information into consideration together with the slow pace with which potential information can be "filtered" (qualified selection) such that we get from it a qualified ("actual", e.g. factual <u>and</u> meaningful, perhaps very complex) information.

Risks as well as crisis have a quantitative (measurable) and a qualitative (non measureable) component. Measured data allow the calculation of the occurrence probability of risks.

Due to the finite observation windows we will never get 100 % occurrence probability!

The cultural background determines the collective consciousness of a nation. Together with the economic situation this consciousness sets within today's national states the risk acceptance levels.

As can be shown with the example of the fear of flying, the qualitative aspects of risks dominate (irrationally/emotionally) almost always the quantitative ones. Both have to determine political decision finding processes. In general governments should not start risky projects when there is no public insurance company ready to insure it, because this indirectly shows that the public risk acceptance level has been exceeded.

*The higher the occurrence probability of dangerous events, and the more accurate it is known, and the lower the risk acceptance levels, the faster decisions for actions must be made. However, very often the necessary actions get postponed with the argument "We still need higher occurrence probability before we act". This **non-decision** procedure is very **dangerous** because of the time delay and accumulation problems,. The discussions on global change show this clearly. For example there is now about 80 % probability that the predictions of the global warming are correct. However, there is also about 20 % chance that a completely different scenario will occur. If we would start to minimise much more the flow of matter and energy used by man - nature does this very effectively within its "biocybernetic" system since millions of years - i.e., strive for more eco-efficiency then **we can slow down for***

***both cases the pace of change**, i.e. reduce the risk of sudden drastic changes, e.g. a sudden fast encounter with the bifurcation point of our "chaotic environment".*

Re-introduction of the principle of trial and error, the more the complexer the systems we deal with and the use of **biocybernetic** principles should **dominate** linear technocratic thinking and model calculations. This means for example that functioning computerised complex, special administration systems should be improved in small steps and not replaced by new ones that have little or no interface with the old one. This is not only very risky but in any case also very time consuming and thus very costly and uneconomic. In times where saving is a must such activities are irresponsible -even if they might be in part explained or excused with the Emperors New Cloths syndrome - and should be fined if there is no other way to stop this indirect partly very large damage to the national economies.
Biocybernetic system control methods should dominate linear technocratic control methods the more the complexer the system gets.
Preservation of ecological (biological) diversity - see appendix 1 - a presupposition for a successful **conserving utilization of our environment** (mostly denoted sustainable development), which implies for example that scientists, who can act as "human catalysts" the following:

- try to make better understandable, to the public the negative consequences of the principle time dealy and accumulation effects in our environment. In order to minimize them we need not only more and better **early warning and monitoring systems** but also a faster, **qualified selection of (useable) information** out of the rapidly growing (accumulating) amount of "potential" information and more **informal dialogues** between the disciplines, the generations and the cultures.
- help to make better understandable the advantages and disadvantages of the "uncertainty domain" and the need for an optimization of interfaces of all kinds
- help to induce only such anthropogenic changes that in the long run very likely lead to an **all win game** and which in the short run at least lead to a **no looser game**

Preservation of economic diversity, which is the presupposition of further successful economic development. This means for example that the author hopes that an European Community will contribute, e.g. a social-democratic alternative - with a modified/revised social system - to the envisaged "20:80 Tittytainment society" envisaged in the USA and the "feudal" market concept in the Orient/Asia and thus supplement the anti-diversity concept of "a quick dollar"

11.2 An Example of the data growth rate problem

(Dieminger et al. 1996, Hartmann 1996a, b, 1997c)

Using **atmospheric research** as an example one can demonstrate the large information growth rates of the last decades, especially the increasing surplus of **primary information** ("raw data") and the increasing lack of direct, fast useable **secondary information** (qualified filtered "raw data"). At the beginning of the decade 1990 there were more than 2,5 x 10^{14} bit of (atmospheric) information available with an annual growth rate of about 10 %. If these 2,5 x 10^{14} bit would have been put - in normal print - on DIN A4 pages, each 1mm thick, the generated (virtual) row of books would have a length of **362 km.** The new generation of "atmospheric satellites" like ENVISAT etc. are not only capable to produce data flows that are more than a magnitude larger than those at the end of the 1980s, but they have been designed to do so. This implies that the mentioned growth rate of 10% per year will be strongly exceeded. It is estimated that per annum about the same amount of data can and/or will be produced that have been stored until now, i.e. at the end of the **year 2001** the row of

books has reached at least a length of **nearly 800 km**, i.e. about the distance between Hamburg and Munich.
Another example of an INTERNET information search with conventional search machines (Lycos, search October 1999) is shown in the following table:

Search question	**Hits**
Water	**1858896**
Water vapour	**4707**
Water vapor	**35206**
H_2O	**23301**
Atmosphere	**290324**
Water and Troposphere	**1695**
Stratosphere und Water	**2652**
Water and Atmosphere	**65189**

It became clear that not only in the very general INTERNET information system there is insufficient (qualifying) selectivity but also, however to a much smaller degree, in today's special scientific-technical the poster dealing with O_3 and H_2O retrievals. This probably at the expense of giving more incomplete coverage of the topic.
Information ordering principle
Table 3 shows a coarse presentation of the major information ordering principles with the transition from humanities – meant in a restricted (partial) sense - via cosmology, geoscience to physics (e.g. laboratory physics). It shows that geophysics is between the two extremes. Today's large information growth rates reveal more and more the principle problems that we encounter with hierarchical information ordering. This seems at first glance quite surprising and needs a more detailed explanation of the difference between hierarchical and non-hierarchical information systems. The retrieval strategies, or user-friendliness are very much dependent from the ordering principle which is applied for the data storage together with a relevant thesaurus.

11.3 Scientific Data between validation imperatives, oblivion and fraud

(Hartmann, 2000).
The causes and consequences of the three processes data filtering, data oblivion and data manipulation are very different indeed. As, however, from a scientific point of view the negative consequences of fraudulent manipulation are both the most detrimental (materially and in terms of credibility) and the most unpredictable, it is worth while taking a closer look at the causes.
1st cause: the growing competitive pressure generated by the reduction of (government) funding, plus the fact (largely attributable to the data explosion) that an insufficiently clear distinction is made between a) the necessary, user-friendly, qualifying[2] filtering of data (including validation[3] and verification[4]) and b) fraudulent data manipulation.

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[2] **Qualifying filtering** is necessary because of the colossal data growth rates and the fact that as the quality of data decreases the legal and financial risks incurred in using them increase.
[3] **Data validation**: systematic errors can only be measured if the same physical object is measured at least once more with a measuring configuration based on a different principle from the first. The comparison of these two (or more) sets of data is called validation. The degree of agreement between the two sets of data (a standard established **intersubjectively** by the scientific community) determines the "value" of the data, i.e. the degree of reliability the data can claim, i.e. their quality. Data validation is unthinkable without this **participation by the community**. (The value thus determined is called "**accuracy**" (indeterminacy)).

We are dealing here with a highly dangerous, **self-reinforcing** factor which has been operative in exacerbating the public distrust of "**objective**" science, a distrust reinforced by the increasing bureaucracy encountered at all turns. We must also bear in mind that for their indispensable verification and validation "**objective**" data require the **intersubjective** approval ("evaluation") of the scientific community; this, in its turn, means that they cannot be entirely objective in the true sense of the term.

2nd cause: the negative effects of the growing number of technologically complex large-scale systems.

At present these effects are responsible for an increasing hostility vis-à-vis science in general; at the same time, they are thrusting the scientists and engineers working in research and development (R&D) into a hitherto unaccustomed **culprit or scapegoat role**. So far, legal protection (source responsibility etc.) in this connection has been inadequate (I refrain from touching on the moral aspect). The extent to which *administrations* require scientists and engineers to "**operate**" (as opposed to "**co-operate**") is proportional to the degree to which necessary and sensible administration turns into counter-productive **over-administration**. By this we mean the kind of senseless "*red tape*" which (in the long term) has an (economically) counter-productive, foot-dragging effect (which is truly "destructive" through the negative synergies it generates) as opposed to the supportive effect (positive synergies) that any form of administration worthy of the name may be rightly expected to have.

3rd cause: the (today) unavoidable mixture of public/private in the use and marketing of the results of basic research for economic/industrial purposes; the inadequately established awareness of the complementarity principle, in conjunction with an insufficiently scrupulous and judicious use of language .

4th cause: the fact that in many nation states and societies there appears to be (more or less tacit) agreement that added-value (e.g. money value) is the real **value** (*Is this added-value really the greater value?*)

The fact that the principle of "more and quicker" is an eminently marketable rationale has led to a situation in which a) the "**velociferic**"[5] trend can be expected to gain ever greater momentum (this development is bound up with an ill-advised rationalization drive curtailing the indispensable areas of "tolerance" in the interplay between humans and machines) and b) there is also insufficient perception of the ethical obligations inherent in science as a profession. Accordingly, the (legal and financial) risks go on mushrooming in the (highly) developed nation states, notably because there is less and less time a) for the necessary optimizing of the man-machine adaptation process, and b) for achieving better understanding of, and skills in dealing with, (non-linear) complex hybrid systems at the software and hardware levels. Hence the incessantly ballooning costs for the prior prevention (prophylaxis) and subsequent elimination of the damage attendant on these risks.

Remarks

The celerity of technical progress has made it increasingly difficult to process older data. In some cases it is impossible today to process data going back further than 10 years. This has given rise to the term "**technical amnesia**". This new form of "knowledge death" not only generates a staggering cost spiral, it also confronts us with some other very unpleasant

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[4] **Data verification** means repeating the measurement independently with the same equipment, using the same hypotheses and references, and then comparing the results. The cross-correlation between two sets of data obtained independently of one another is a gage for the verification, whose standard (quantitative value) has to be agreed on **intersubjectively** by the scientific community. (The value thus determined is called "**precision**" (indeterminacy)).

[5] The term "**velociferic**" was coined by J.W. von Goethe in 1825 from "velocitas" and "Lucifer". It describes first and foremost the negative consequences of acceleration. Our present age - sometimes referred to as the Age of Acceleration - is outstandingly "velociferic".

problems. So far, and for reasons difficult to fathom, very little has been done to obviate the causes, so that little improvement can be expected in the near future. This is a crucial hazard for science because the costs thus arising will probably devolve to a very high degree on science itself, i.e. they will have to be met from available funding, quite simply because scientists, technologists and engineers are regarded as the main culprits.

Science between private and public

The present problems of privatisation of scientific activies is amplified by the fact that we do not exactly know what is public or private in science. The concept that science is not public, but might be reserved for private use only not only contradicts the nature of (modern) science as we understand since the antiquity, but is also illusionary. Private knowledge that is not exposed to intersubjective discussions and public critics is not „scientific„ in ist original sense. Culturally spoken this is a step backwards into arkane, archaic religiosity respectivley into the ominous knowledge of the gnostic „initiated„. The political responsibility of the scientists and the (political) control can only be guaranteed if the public domain exists and to the degree with which it functions. The recent scandals with scientific data, especially in Germany, accusing scientists of a falsification of data („data forgery„) makes this quite clear. However, they make it also clear that we need to be more specific and/or have to know what we mean when we talk about falsification. In the mentioned case there existed - different from the falsification of a painting - no original only the „invented„ data set, which was sold as a real measured data set. In the future we will be also faced with problems that will range from careless use to intentional (criminal) misuse of existing data and from careless to intentional (criminal) manipulation of existing data. The discussion of calibration, verification, validation, and value added validation in should help in this context to make scientists and non scientists more aware of the legal consequences that might be involved in a not thouroughful use of somebody elses data and it should help them to defend themselves better and more succesful against unjust or incompetent accusation.

New Copyright Aspects

The EU Directive 96/9 is binding for all member nations since January 1998. It makes for the governmental institutions a privatisation of the following activities simpler and more attractive:

1. The acquisition of scientific data
2. The public availability of such data as well as their handling

This directive guarantees the private enterprises an „ ill- defined„ and all comprising protection for 15 to 25 years - with proper data updating or upgrading even much longer – for a profitable marketing of the their data. This comprises also all old data that these enterprises now administrate and that they in general got cost free.

The direct consequences for all governmental research activities will be that the costs for needed external data will increase. If the national research budget remains constant or even decreases this implies an indirect further reduction in the available research budget. Not only the direct needed data will be more expensive than the hitherto payed minimum fees but also there will be costs for each use of the database, e.g. for browsing („pay per use„). Further more it will get much more complicated and much more time consuming to collect (internationally) the needed data, which is contra-productive to our present working hypothesis, especially when the Non-European partners have different regulations (laws) and/or may like to stick to the old very succesful data exchange policy which was internationally agreed and established by the International Counsil of the Scientific Unions (ICSU) for the International Geophysical Year 1957/19958. New agreements will take several years especially when also international court cases have to be also taken into consideration. In this time span we have to live either with more expensive data, fewer data, or even no data.

The latter might be desastrous for longer term environmental trend investigations, especially considering relevant „early warning systems„.
However, there can also be expected direct negative political consequences, especially with regard to the international scientific cooperation with former Third World Nations, now the low industrialised Second World Nations. These nations have very often only small quantities of data to offer, but which are of high qualitiy. Since the judging of the value of scientific data is very difficult it is predominantly based upon quantitative aspects rather than on qualitative ones. This implies for the poor nations that they will have to pay much more than the present minimal costs in order to get the same amount of data as hitherto. It is very unlikely that they can afford that, i.e. they will be more or less excluded from the present data exchange in geoscience. This implies that these nation will not only get economically poorer but also get scientifically less informed. This will additionally increase the political tension between the „poor and rich„. This cannot be the goal of European politics. If this is so then the directive 96/9 must be much less restrictive enforced then hitherto discussed and more practicable exemptions must be implemented. The short term governmental savings politics is of course today beneficial for the governmental budget but at least in the geoscience domain it will produce much higher long term costs and very likely also considerabel irreversible damage, i.e. it will be a negative bargain. These problems led to activities described in the next chapter.

11.4 Budapest Open Access Initiative

An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the world-wide electronic distribution of the peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and quest for knowledge.
For various reasons, this kind of free and unrestricted online availability, which we will call open access, has so far been limited to small portions of the journal literature. But even in these limited collections, many different initiatives have shown that open access is economically feasible, that it gives readers extraordinary power to find and make use of relevant literature, and that it gives authors and their works vast and measurable new visibility, readership, and impact. To secure these benefits for all, we call on all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way. The more who join the effort to advance this cause, the sooner we will all enjoy the benefits of open access.
The literature that should be freely accessible online is that which scholars give to the world without expectation of payment. Primarily, this category encompasses their peer-reviewed journal articles, but it also includes any unreviewed preprints that they might wish to put online for comment or to alert colleagues to important research findings. There are many degrees and kinds of wider and easier access to this literature. By "open access" to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for

copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.

While the peer-reviewed journal literature should be accessible online without cost to readers, it is not costless to produce. However, experiments show that the overall costs of providing open access to this literature are far lower than the costs of traditional forms of dissemination. With such an opportunity to save money and expand the scope of dissemination at the same time, there is today a strong incentive for professional associations, universities, libraries, foundations, and others to embrace open access as a means of advancing their missions. Achieving open access will require new cost recovery models and financing mechanisms, but the significantly lower overall cost of dissemination is a reason to be confident that the goal is attainable and not merely preferable or utopian.

To achieve open access to scholarly journal literature, we recommend two complementary strategies.

I. Self-Archiving: First, scholars need the tools and assistance to deposit their refereed journal articles in open electronic archives, a practice commonly called, self-archiving. When these archives conform to standards created by the Open Archives Initiative, then search engines and other tools can treat the separate archives as one. Users then need not know which archives exist or where they are located in order to find and make use of their contents.

II. Open-access Journals: Second, scholars need the means to launch a new generation of journals committed to open access, and to help existing journals that elect to make the transition to open access. Because journal articles should be disseminated as widely as possible, these new journals will no longer invoke copyright to restrict access to and use of the material they publish. Instead they will use copyright and other tools to ensure permanent open access to all the articles they publish. Because price is a barrier to access, these new journals will not charge subscription or access fees, and will turn to other methods for covering their expenses. There are many alternative sources of funds for this purpose, including the foundations and governments that fund research, the universities and laboratories that employ researchers, endowments set up by discipline or institution, friends of the cause of open access, profits from the sale of add-ons to the basic texts, funds freed up by the demise or cancellation of journals charging traditional subscription or access fees, or even contributions from the researchers themselves. There is no need to favor one of these solutions over the others for all disciplines or nations, and no need to stop looking for other, creative alternatives.

Open access to peer-reviewed journal literature is the goal. Self-archiving (I.) and a new generation of open-access journals (II.) are the ways to attain this goal. They are not only direct and effective means to this end, they are within the reach of scholars themselves, immediately, and need not wait on changes or legislation. While we endorse the two strategies just outlined, we also encourage experimentation with further ways to make the transition from the present methods of dissemination to open access. Flexibility, experimentation, and adaptation to local circumstances are the best ways to assure that progress in diverse settings will be rapid, secure, and long-lived.

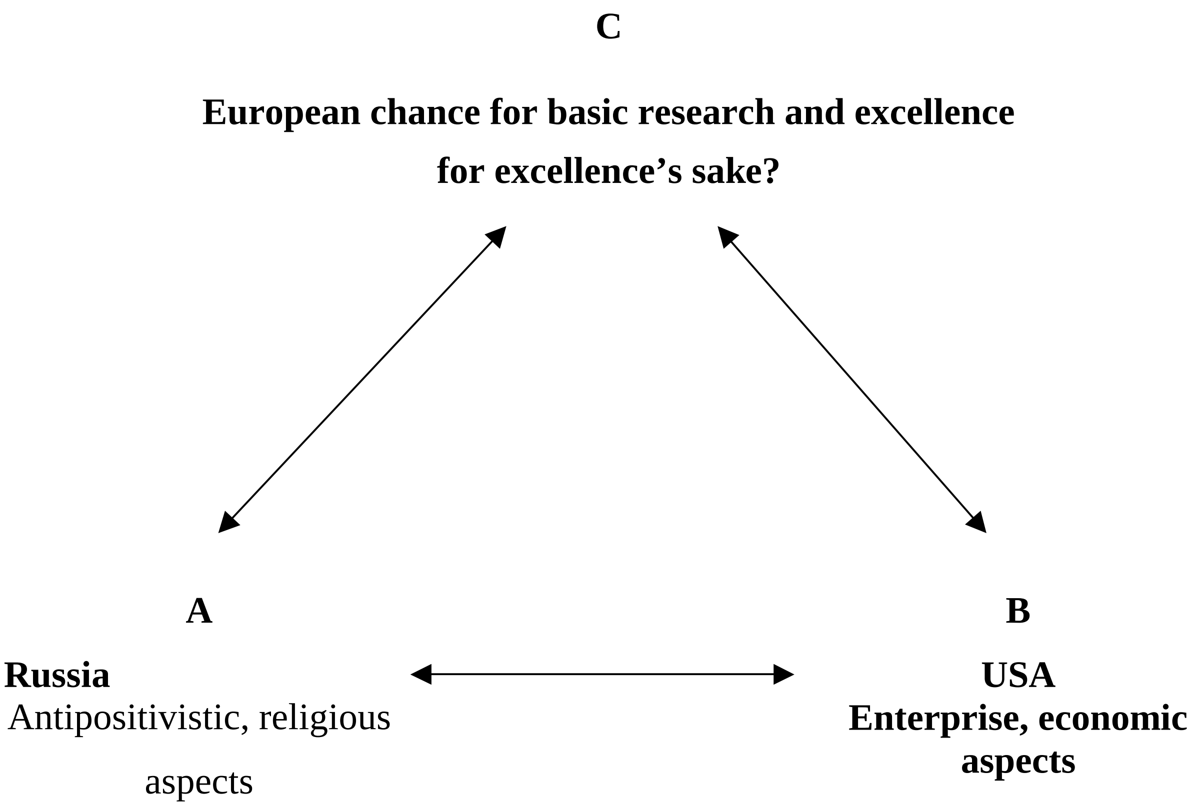
The Open Society Institute, the foundation network founded by philanthropist George Soros, is committed to providing initial help and funding to realize this goal. It will use its resources and influence to extend and promote institutional self-archiving, to launch new open-access journals, and to help an open-access journal system become economically self-sustaining. While the Open Society Institute's commitment and resources are substantial, this initiative is very much in need of other organizations to lend their effort and resources. We invite governments, universities, libraries, journal editors, publishers, foundations, learned societies, professional associations, and individual scholars who share our vision to join us in the task of removing the barriers to open access and building a future in which research and education in every part of the world are that much more free to flourish.

February 14, 2002, Budapest, Hungary (signed by the participants)
See also: http://www.soros.org/openaccess/

12 Figures and Tables

Fig. 1

Space research “philosophy” after and prior to cold war competition



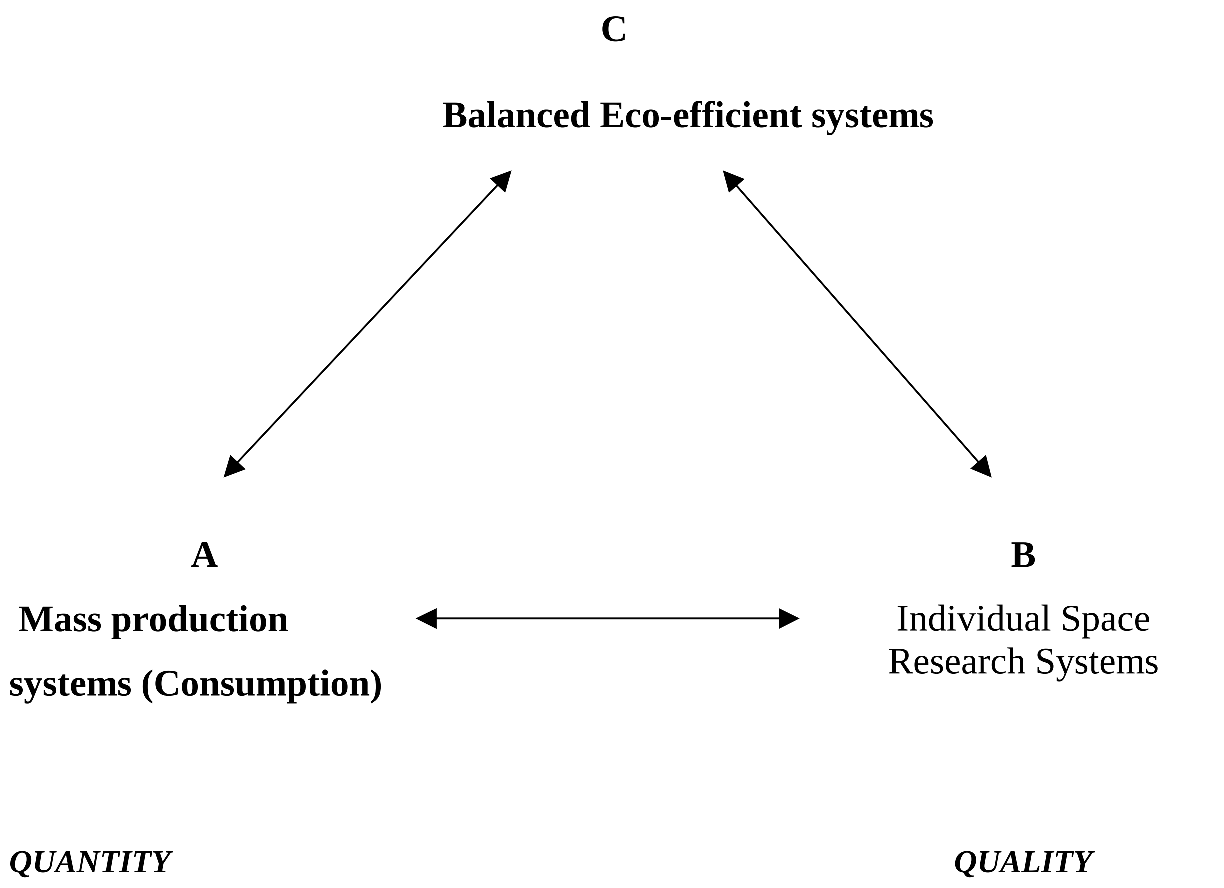
Remarks:

- **What are the chances for and chances through Space Research in the rest of the world like in Africa, the Arab world, Asia, Australia, and South America?**
- **Can Asia benefit from its culturally based striving for balance between what we do and how we do it?**
- **The most intelligent Space Research – or exploration system – must be designed and built according to the principle “excellence for the excellence’s sake” which allows the optimal synergistic combination between basic research and applied research.**
- **The ultimate goal of Space Research is our cosmos, which is the largest open system - in space and time -, which has also intelligent inhabitants who try to understand it, amongst others through cosmology. Today modern cosmology – however also many other science domains - call for a better balance between Space research and Time research, the latter also gets increasingly a subject of theology.**

  (see also fig. 3a)

Fig. 2

Balance between What we do and How we do it



Remarks

- **Quality in Space Research is characterised by: Special (single or very few) products, long-lived, (durable and reliable under interplanetary conditions), expensive, resource extensive, high capital intensive, slow capital return, i.e. it takes a longer time until the technological (by-)products can be economically sold for daily life uses. Special Quality Assurance (QA) and Quality Control (QC) procedures have been developed in this context. They have been supplemented by intensive and expensive security procedures in context with manned space research.**
- **The term quality is related to <u>vagueness</u>. This is intensively discussed in context with the antique Greek sorites paradox.**

Fig. 2a Example for fig. 2

C

<<Local Acting>>
***DEREMOTOX or Local Eco-village -**

system Development (LED)
******(LEDGEM part 1)
Sustainable, durable resource efficient mass production of (simple basic) low cost goods through Research and Development (R&D).
Creation of new markets, medium capital intensive, high labor intensive

A

<<Regional Acting>>
Mass production

Short-lived, low cost throw away goods, resource squandering.
High capital intensive, fast capital return, low labor intensive.

↔

B

<<Global thinking>>
Global Earth Monitoring (GEM) from Space. (R&D intensive**)**
(LEDGEM part 2)
Special (single) products, long-lived (durable), expensive, resource extensive.
High capital intensive, slow capital return, Medium labor intensive.

Remark:
We must distinguish between purchasing products or leasing their functions. The latter is in general more eco-efficient and user friendly. See also fig 5a.

DEREMOTOX:** ***Desert Soil Recultivation and Monitoring of (phyto-) Toxicity). A pilot project in three phases lasting four years". See Hartmann et al. 2001.

****LEDGEM: Local Eco-village System Development and Global Environmental Monitoring (Report by G. K. Hartmann, June 1998).**

Fig 3a Different ways for reaching quality

Questions:

- **Does quantity "kill" quality?**
- **Can precision "kill" vagueness?**
- **How can intelligent open systems decide between quantity and Quality?**

Fig. 3b

Different data quality

C
High quality (small quantity)
(Combined Optimal Retrieval (COR) with assimilation)
optimal value added

A

Large quantity
low quality

Unvalidated Data

B

Medium quantity and quality

Limited value added
Validation

The detailed presented MAS/GRAS sensor combination proposed for flying on the International Space Station (ISS) is an example of **optimal value added validation**.

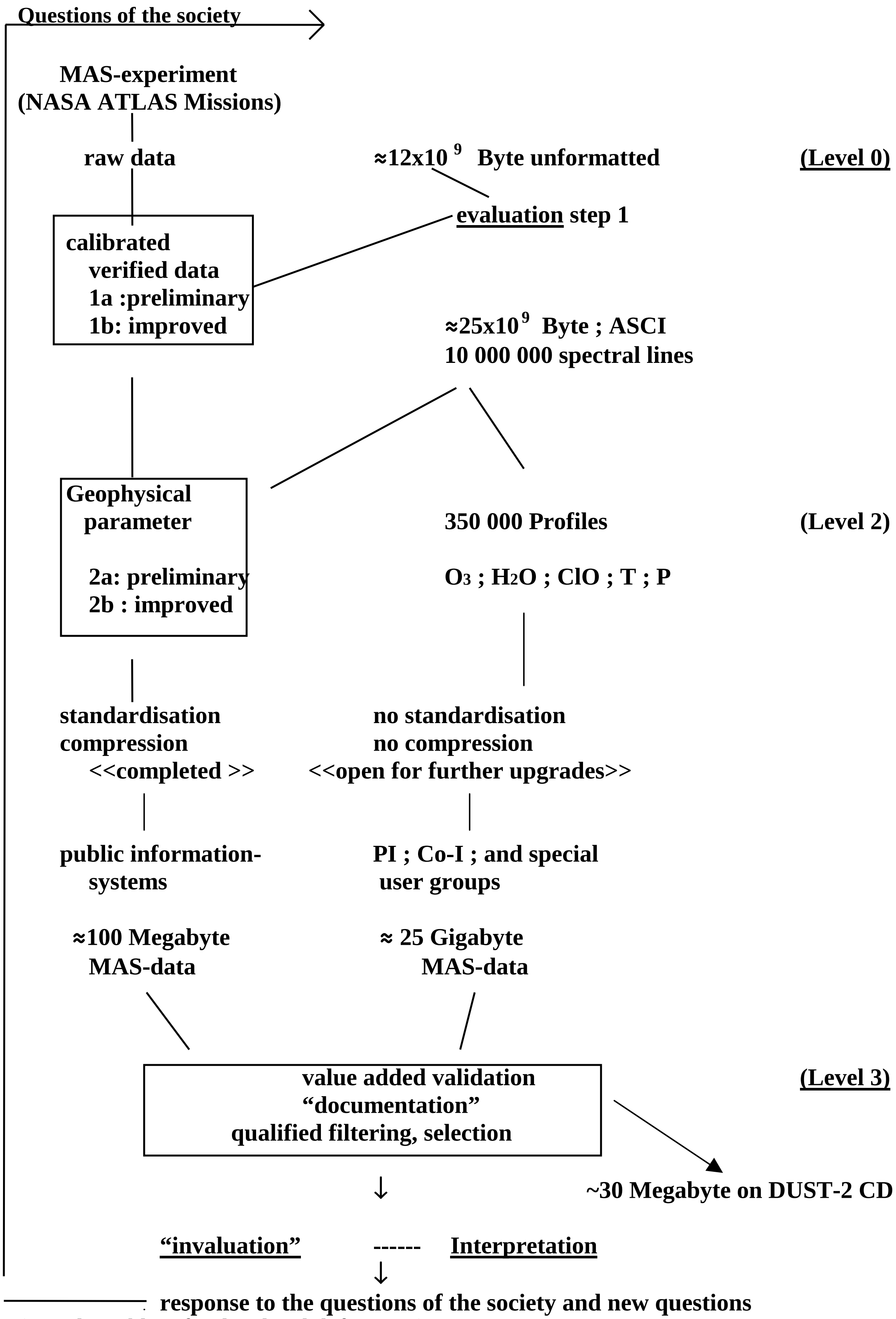
Fig. 3c From an abstract upgrading process to a concrete product: Validation in various upgrading quality steps

Evaluation of measured data	Refinement of a product:
Example: remote sensing	Example: car production
self-consistent, calibrated, deconvolved, raw data	iron-ore
validated data	steel
value added validation	automobile (car)
optimal value added validation	optimal, eco-efficient car
"Invaluation "	socio-economic mobility

concrete, actual, user-friendly use

predominantly by leasing the function

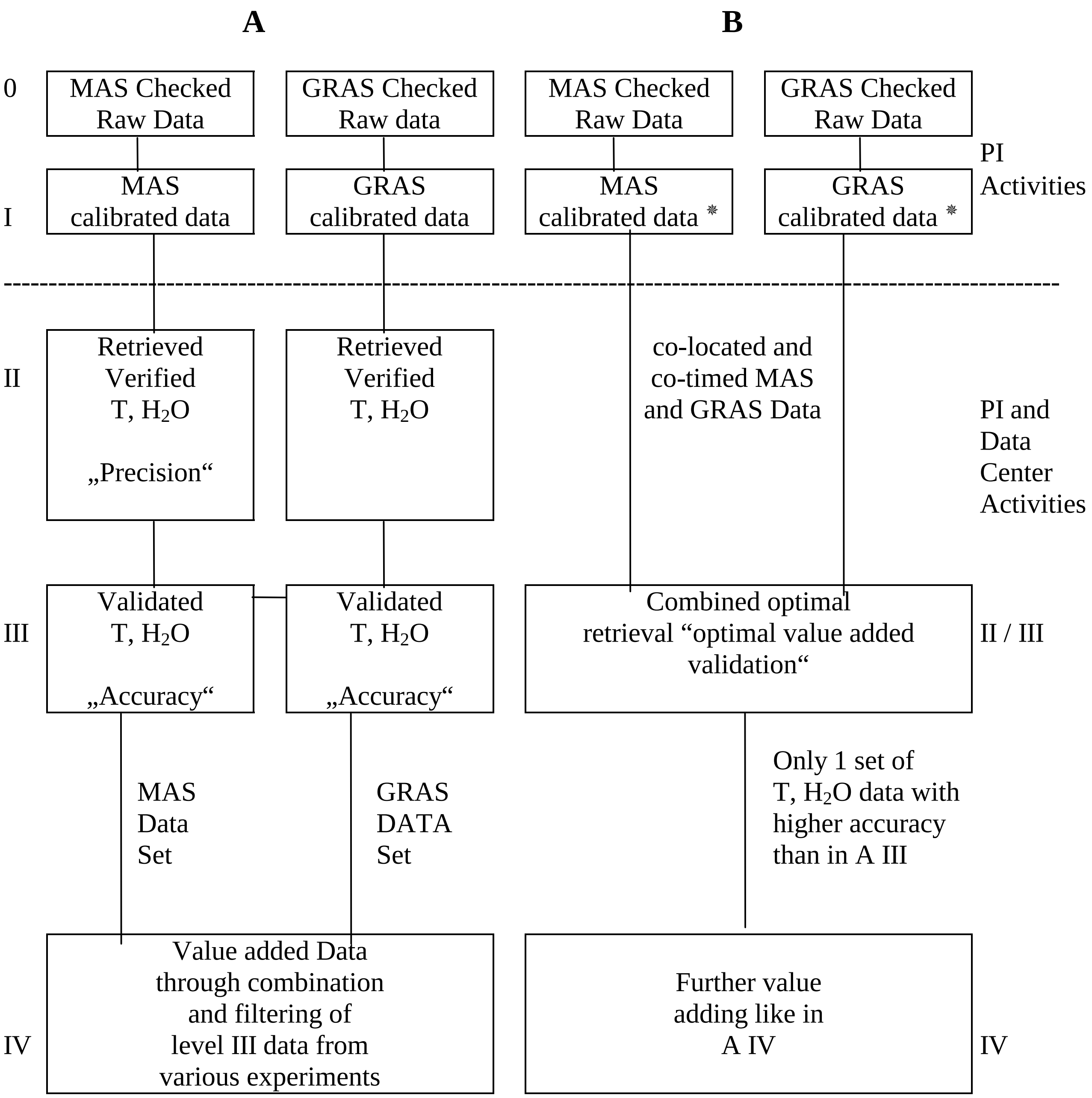
Fig. 4 The three levels of data products: MAS as example



(See also table 4 for data level definitions)

Fig. 4a Two different ways of value adding to data: Example MAS/GRAS

A: Combination and filtering of level III data
B: Combined optimal retrieval: Example MAS/GRAS data



Remark: The more and larger the data sets, e.g. like those from ENVISAT, the more data centers will be and/or must be involved also in activities B II / III and B IV.
(See also table 4 for data level definitions)

GRAS: GPS + GLONASS

MAS: Millimeter Wave Atmospheric Sounder
calibrated data *: this means here: self-consistency check, calibration and deconvolution

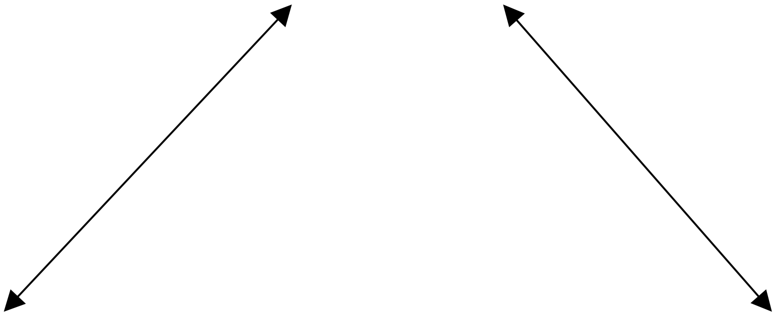
Fig. 5

”Bridging the digital divide”

Part I. The Budapest open access initiative (see chapter 11.4)

C

Open Access (BOAI) to scientific information



A

Copy right

B

Limited Copy left

BOAI implies additional (new) types of qualified filtering methods, e.g. SomAccess, Formal Concept Analysis (FCA) – as mentioned in the ADLATUS concept (2000) -, wavelet transforms, etc.

PART II: From the DUST-2 to the ADLATUS concept:

The DUST-2 concept comprises an interactive interface between local, regional and global scientific data sets using Internet online sources as well as data examples and relevant software for qualifying filtering and graphic data representation which are stored on CDs. See also DUST-2 CD (Hartmann et al., 2000).

The ADLATUS concept transforms this concept by emphasising more educational aspects ranging from elementary schools to high schools. This means for selected scientific-technical domains the creation of more **local competence** in a creative teaching and learning process.

Remarks for Fig 5.

Problem:

"The increasing digital divide"

This phrase describes the combination of two following effects:

- Less useful actual information despite an extrem information growth in the industrialized nations.
- Increasing insufficient access to the available information by the not highly industrialised nations. (The less informed get lesser informed!)

Goal:

Better access to (useful, geophysical) actual scientific-technical-information

Better access means not only to make cost-efficient available faster and more scientific information, e.g. through the cost-free online literature access - but also to obtain more qualified filtered information. This implies amongst others more (local) competence of the users. Then a better understanding of regional and global problems is possible.

Means:

Quest of the international DUST-2 team for further partners:

- **a) for an „upgrade" of the DUST-2 CD**
- **b) for transforming the DUST-2 concept into the stronger education oriented ADLATUS concept**

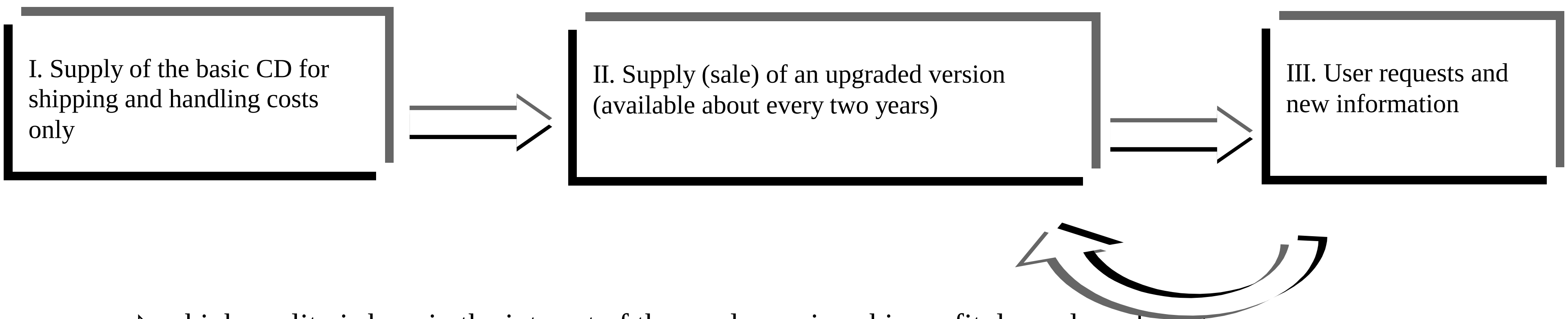
considering:

a) Preparation and supply of further data samples as well as the further development of software for the CD interface function, the (qualifying) data and text filtering, data visualisation and data validation and participation in the Budapest Open Access Initiative and to co-operate with the Copernicus Gesellschaften - www.copernicus.org .
b) In co-operation with the Konrad Adenauer elementary school in Seligenstadt (Hess) and Science-softcon (Hanau) fundraising for a relevant pilot project "ADLATUS fuer Schulen" has been started this summer. www.kas-seligenstadt.de ; www.science-softcon.de

See also the ADLATUS marketing concept in Fig. 5a.

Fig. 5a Adlatus – a more effective interface for Bildung and science

	responsibility		interest	
	producer	user	producer	user
sale of products	Warranty for the product (conservation of status quo)	Taking over the costs for the product, its maintenance and upgrading	Interest in the number of sales (quantity)	Interest in long-term, reliable usage, actuality, and high quality
sale of system use	Warranty for the product (status quo), maintenance, upgrade and improvement	Taking over the costs for the direct use otherwise no responsibility	Interest in long-term, reliable usage, upgrade, improvement, actuality, and high quality	



- ⇨ high quality is here in the interest of the producer since his profit depends on long-term usage.
- ⇨ **guaranteed (long-term!) upgrading of the tool for the user**
- ⇨ maintenance and upgrading is part of the producer task

Fig 6

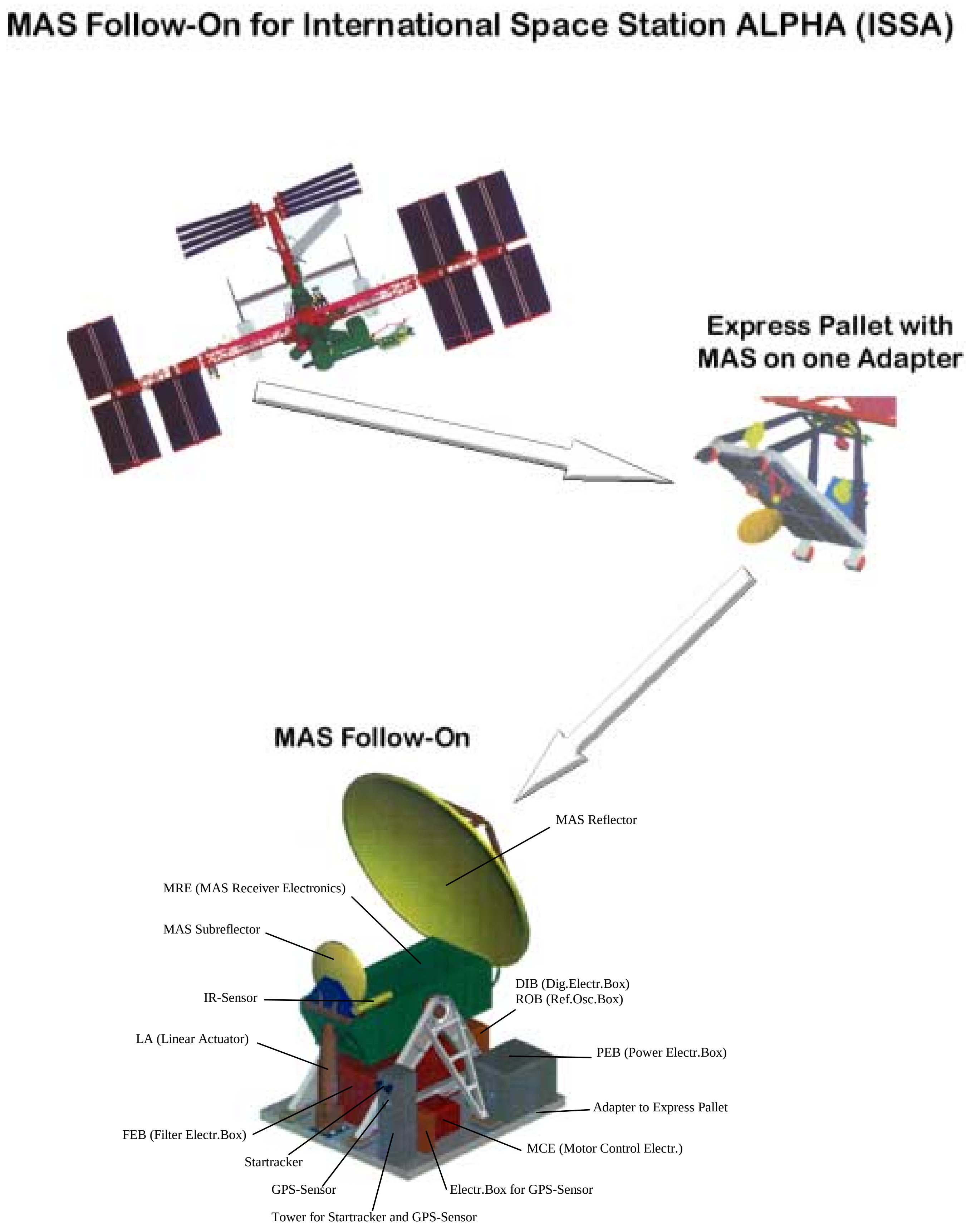
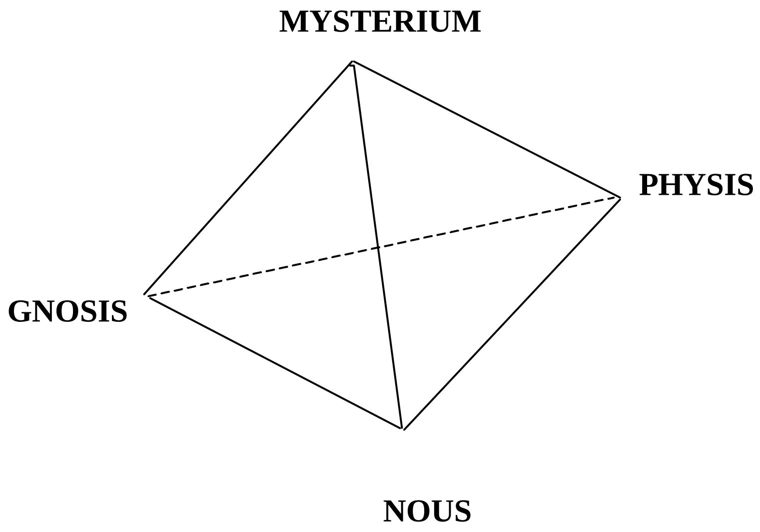

MAS Follow-On for International Space Station ALPHA (ISSA)
Express Pallet with MAS on one Adapter
MAS Follow-On
MAS Reflector
MRE (MAS Receiver Electronics)
MAS Subreflector
IR-Sensor
DIB (Dig.Electr.Box)
ROB (Ref.Osc.Box)
LA (Linear Actuator)
PEB (Power Electr.Box)
Adapter to Express Pallet
FEB (Filter Electr.Box)
MCE (Motor Control Electr.)
Startracker
GPS-Sensor
Electr.Box for GPS-Sensor
Tower for Startracker and GPS-Sensor

Fig. 7. The human being as a filter in the tension between NOUS, GNOSIS, PHYSIS and MYSTERIUM



NOUS: The one who perceives (takes cognizanze of)

GNOSIS: The process of cognition

PHYSIS: That what makes oneself known (recognizable)

MYSTERIUM: The hidden, the the unrecognizable, the (absolute) mystery

Mysterium

Tables

Table 1 URLs for Space research

Information on manned space research can be found via the following links:

http://home2.pi.be/tristar/space.htm
http://www.cet.edu/earthinfo/remotesens/remotesens.html
http://www.oma.be/BIRA-IASB/Public/PubServ/Astronautics/Astronautics99.en.html
http://www.itsf.org/resources/factsheet.php?fsID=68
http://www.ufrsd.net/staffwww/stefanl/ssystem/jupiter/probes/manned.html
http://www.ufrsd.net/staffwww/stefanl/ssystem/jupiter/probes/unmanned.html

MPAe links:

http://www.linmpi.mpg.de/english/projekte/mas/ (MPAe MAS project)
http://www.linmpi.mpg.de/english/projekte/mas/dust-2/ (MPAE DUST-2 project)

Informations on unmanned space research can be found at:

http://roland.lerc.nasa.gov/~dglover/sat/craft.html
MPAe links:

http://www.linmpi.mpg.de/english/projekte/projekte1.html (MPAe research projects)
http://www.linmpi.mpg.de/english/links.html ; (MPAe Links)

Further important links for both space research domains:
http://www.nasa.gov
http://carstad.gsfc.nasa.gov/RSTutorial/start.html
http://carstad.gsfc.nasa.gov/RSTutorial/Intro/Part2_1c.html
Planetary Imagery Sites at the Lunar & Planetary Institute:
http://cass.jsc.nasa.gov/library/LISTS/img_file.html
JPL's Imaging Radar Home page:
http://southport.jpl.nasa.gov/education/classroom/

http://roland.lerc.nasa.gov/~dglover/sat/craft.html
MPAe links:

http://www.linmpi.mpg.de/english/projekte/projekte1.html (MPAe research projects)
http://www.linmpi.mpg.de/english/links.html ; (MPAe Links)

Planetary Imagery Sites at the Lunar & Planetary Institute:
http://cass.jsc.nasa.gov/library/LISTS/img_file.html
JPL's Imaging Radar Home page: http://southport.jpl.nasa.gov/education/classroom/

Table 2

Major applications domains and problems for unmanned spacecrafts

1. Lunar and Planetary Spacecrafts

2. Space Science and Space Observatories

3. Communications Satellites

4. Remote Sensing and Earth Observation

5. Military and Navigation Spacecraft

Major problems of spacecraft experiments

3. reliable inflight calibration complicated, sometimes even impossible

4. need for non linear data compression aboard leads in general to an irreversible data processing product

3. validation possibilites with co-located and co-timed experiments from other satellites are scarce

Table 3 Information ordering prinicples

Humanities, e.g. history Ordering principles 1. Time (*t*)	**-Cosmology – Geosciences Biology - Medicine**	**(Exact)Science -- Physics ordering: 1. Subject (New grouped with already known)**
2. **Space**		2. **Space**
3. **Subject**		3. **Time**
	Further characteristics:	
Mainly:		**mainly:**
Non-stationary		**stationary**
Inhomogeneity		**homogeneity**
Irreversible		**reversible**
Non-classical statistics		**classical statistics**
Information accumulation		**Information compression**
Software problems larger than hardware problems		**Critical data evaluation, (verification, validation)**
Browsing		**Well defined retrieval**
	Interactive storage, retrieval, browsing with multi media	

We live with time, space and subject ordering in humanities – meant in a restricted sense - and subject, time, and space ordering in science (e.g. in physics). Cosmology and geosciences are located between these two poles.
Remark:
Theology and philosophy which have first of all to quest for truth and only then should consider the historical context - this is today often vice versa - extend („transcend") the above, in a restricted context used term humanity. This is also valid for anthropology.

More than 160 definitions for information exist today of the type "information is". This leads not only to confusion but contributes also to the present growing information crisis. The author G.K. Hartmann states: **Information is „created" by a filtering process, i.e. is time dependent. This yields to a new description: <u>„information contains (preliminary) certainties which are made prominent against the (determinable) uncertainty".</u>** In analogy to radio science, the determinable uncertainty: the noise, is as important as the preliminary certainty: the signal. How much the signal is pronounced with respect to the noise is determined by at least two time periods.

Table 4
Definition of Data Set Processing Levels
(From the EOS Reference handbook - with insertions proposed by GKH)

Data level	Description
0	Reconstructed unprocessed instrument/payload data at full resolution; any and all communication artefacts (e.g., synchronisation frames, communication headers) removed
1A	Reconstructed unprocessed instrument data at full resolution, time referenced and annotated with ancillary information, including radiometric and geometric calibration coefficients and geo-referencing parameters (i.e. platform ephemeris) computed and appended but not applied, to the level 0 data
1B	Level 1 data that have been processed to sensor units (not all instruments will have a level 1B equivalent)
1C	TRMM specific quality content of level 1B precipitation radar and ground validation data
2	Derived geophysical variables at the same resolution and location as the level 1 source data ***Insertion by G.K. H.: 2A Verified data with given „precision“ (relative error)*** ***2B Validated data with given „accuracy“ (systematic error)***
3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency
4	Model outputs or results from analyses of lower data levels (e.g. variables derived from multiple measurements) ***Insertion by G.K. H.: 4A Model outputs.*** ***4B Data assimilation*** ***4C Value added validation***
4D	**optimal value added validation**

This level 4 definition approximates very closely the former definition of level III data.

Table 5

Consequences of finite measurements and different types of data: exemplified with Earth's atmosphere

Data from the Earth's atmosphere belong to the domain of geophysics, where we have the following data types and problems, given in a brief summary (A-E):

A) Three types of geophysical data:
1. Long-term data (time series character, service character).
2. Short-term data (sampling character, project character).
3. Constants (laboratory physics character).

B) Three types of time series data:
1. Persistent data (signals).
2. Quasi-persistent data.
3. Non-persistent data.

C) Problems with time series data:
1. Data from stationary effects or from non-stationary effects (turbulence, dissipative structures).
2. Band pass filtering → "uncertainty principle" → blurredness of persistent and non-persistent data.
3. Series correlation.
4. Correlation or association, significance levels.
5. Linear approximations (filtering),i.e. no feedback effects.
6. Sampling effect errors and quantization errors.

D) "Finite Measurements"

Measurements imply to impose a finite spatial and /or temporal limit on the event, thus measurements can only describe part of the reality.

Principle Problem: Finite measurements and finite linear equipment should serve for infinite prediction and/or accuracy/precision.
This implies:

⇒ Influence of uncertainty principle.
⇒ Only finite accentuation of signal.
⇒ Signal plus irreversible mixture between signal and noise („new noise“).
⇒ Filtering ⇒Time-spans are linked with information as well as some assumptions (Pre-understanding, "a priori information").

E) Data sources and users in science
a) Basic Research (discovery).
b) Applied Research (invention).
c) Development [usage of (a) and (b)].