IAHR/IWA/IAHS HydroInformatics Joint Committee

Working Group on "HydroInformatics Vision"

HYDROINFORMATICS VISION 2011

Synoptic Report of the Working Group

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Content

1. Introduction – working group organisation and reporting

What is currently called "Hydroinformatics" (HI) has been developed within IAHR (International Association for Hydro-Environment Engineering and Research) and IWA (International Water Association), more precisely driven by a Hydroinformatics joint Committee of both organisations. The Committee is currently being in the process of enlargement to the third organisation: IAHS. The joint HI Committee set up a Working Group on *Hydroinformatics Vision*; the target of the Working Group was to produce two documents within limited time (end of April, beginning of May 2011):

(a) A full Report to the joint IAHR/IWA/IAHS Hydroinformatics Committee Leading Team. It is understood that the vocation of the Report is to be made available at the same time to anybody interested in the field.

(b) A draft of shorter Synoptic Report resuming the full Report. Present document is a draft of this Paper to be presented through the Leading Team of the Committee to the governing bodies of the three organisations (e.g. IAHR Council) and also published.

It must be understood that there was no preposterous ambition within Working Group and the authors of the Report to produce a kind of an "*HI vision manifest"* for the future. The ambition is to describe current situation as stemmed from years of experience, to enumerate a number of future (say next 10 years) developments and possibilities as are foreseen by the authors today, to produce a point of departure for further discussions and exchanges of views and, at the same time, to propose a number of practical actions, to be implemented now, and of aims which result from this vision of the future.

N.B.: *the readers of the present Synoptic Report interested in arguments leading to its statements and in developments leading to its conclusions are encouraged to take knowledge of the full Report and its Appendices*[1].

From the point of view of the set up of tasks within Working Group there is a "Core Working Group" of 4 persons who were taking care of writing, editing and organising the work. Then there are three "Circles" of people interested in HydroInformatics and in the results of the Working Group activities:

- The 1st Circle of volunteers to read consecutive versions of the Report and to respond to the "Core" within very short delay of the order of 10-15 days with criticism, modifications, comments and complements. This 1st Circle counts some 15 persons.

- The 2nd Circle of volunteers. They agreed to the same as the 1st Circle but with the delays much longer (of the order 4-6 weeks) and with less stringent engagement. This means that their comments and criticism may not be integrated in time in all consecutive versions. This 2nd Circle counts some 20 persons.

- The 3rd Circle of persons, who, the Core group of Working Group feels, should be informed about the progress. Although immediate reactions of these persons were not expected, their comments and opinions were of course welcome and taken into account.

Thus the 1st Circle members are really co-authors or, at least, permanent reviewers of the Working Group production: their intervention guarantees the quality of the results; the 2nd Circle members are "more passive" reviewers of this production at intermediate stages.

To make the common work more efficient and easier to all concerned there has been opened a ***discussion forum on Internet***. The address of the Web site is
http://groups.google.com/group/hydroinformatics-vision.

[1] Appendices of the full Report are: Appendix 1: Authors and Reviewers of the Report; Appendix 2: Some Research Fields for HydroInformatics; Appendix 3: @qua network; Appendix 4: List of contacts to be set up with international working groups and conferences.

This **HydroInformatics Vision Forum** was open automatically to the members of 1st Circle and 2nd Circle until the end of the Working Group task. Others who are interested to participate in forum discussions were most welcome.

The above described organisation results from the wish of the "Core" to make sure that the views presented in the Report reflect, or at least are accepted, by sufficient number of the HI Community members in order to avoid major errors or omissions.

2. Hydroinformatics –where do we stand?

Hydroinformatics has a tradition and remarkable merits in the development of computational simulation software for physical processes of the water-environment world. Nevertheless it is felt that for a long time now there has been a *limitation* in innovation areas as compared to developments and evolution of what is called "water sector". Hydroinformatics, which within the IAHR stemmed from the activities of numerical simulation and hydrodynamic modelling, is still, within this environment, *generally* understood in such limited way. Steps are now needed to reshape Hydroinformatics to the needs of today and, even more important, of the future.

Indeed, already now and more in the future there is the need for creative solutions to the challenges coming about with the move of society towards open information, to globalisation of business and markets and to networking in the Internet. The potential and options of modern Information and Communication Technologies (ICT) will be implemented everywhere within the water domain. Question is: will these future developments occur without being based on, influenced, helped by the experience of the IAHR/IWA hydroinformatics currently existing community or does this community steps aside and constraints its interest to modelling technologies in hydrodynamics? In other terms, there is an alternative:

- Either this community concentrates on academic research in hydraulics and hydrology using to that end all ICT developments available and leaving water sector industry and stakeholders to "use the results of the research".
- Or this community will participate proactively, offer and use its past experience, in developing a new approach to water sector activities of research, implementation, applications, communication, information management, in common with all stakeholders (engineering, management, political, citizens), through innovative interwoven way of collaboration ?

For the second possibility of the alternative (second bullet point above) the framework of the existing (since 1992) IAHR/IWA Hydroinformatics Committee is obviously too limited. That is why first of all enlargement of the Committee to the IAHS (International Association for Scientific Hydrology) was decided couple of years ago but up to now has not been implemented effectively. More significantly the Committee, choosing to follow the second possibility of the alternative decided to create a Working Group with the purpose to try to define a ***Vision*** for this domain. With obvious background thinking that the future must not be constrained by IAHR/IWA/IAHS limits but must extend bridges towards ***all*** domains of interest concerning water where hydroinformatics concepts exist or will appear.

3. *HydroInformatics Vision* aspects as perceived by the Working Group

What is a "vision"? Various aspects of HydroInformatics (HI) vision as conceived by the authors of the Report are:

- *General aspects*: HI is a domain of science and technology covering the management of information on the field of water and related subjects. This does not provide clear cut frontiers and allows for overlapping with other domains. It does not define any specific (except for the word "water")

clarification or limitations. Both drinking water pressurised pipe networks and socio-economic consequences down to legislation concerning water use may serve here as a typical examples of this domain. **Vision:** What this domain will become within next, say, 10 years?

- *Specific aspects:* HI ambitions to coordinate sciences and technologies related to water and water sector thus assuming horizontal role in interweaving the findings, initiatives, policies. **Vision:** The interweaving, coordinating and synergetic use of findings and technology will become ***conscious*** and ***organised*** activity. In other words: post industrial ICT revolution and increasing importance for humanity of water will at any rate tend ***automatically*** to link all strings together. This unavoidable evolution can be guided, accelerated and aided to reduce as much error as possible first through the ***wide*** recognition of that situation by ***concerned stakeholders*** and then thanks to their ***conscious*** attitudes and activities. This can be considered as the vision for ambitious community. The vision leading to ally and unite concepts in ways most useful for human purposes. It involves the problems of ethics, sustainability, future of the planet earth, etc., etc., although the Report has no ambition to develop them all.
- *Organisational aspects*: Related to HI ambitions but, this time, to coordinate and interweave organisations, governments and individuals such as IAHR/IWA/IAHS Committee on Hydroinformatics, governmental agencies, etc. Those are many visions, not just one! **Vision:** Staying within our (current HI community) frontiers of possibilities and competences the ambition could be limited to build bridges over the gaps, to act upon educational aspects, to encourage research in certain directions, to convince the stakeholders from and outside of engineering domains to work together using means of information management *and* of exchange that we can supply.

4. Changes that condition HydroInformatics vision-background

The background against which one must consider the place of HydroInformatics changed dramatically during last decade. Essential characteristic of the change in water/environmental areas is the reciprocal interactive evolution of societal and technical domains.

Water/environment issues, within these present days of climate change and growing global population have become a major challenge for human economies and their social organisations. They necessitate more and more complex approaches at a more and more trans-national level. The essential aim of such management is to avoid, if possible or at least minimise, the risks of crises in water supply and waste water treatment for populations, in water scarcity for irrigation, in management of consequences of floods, and so forth. The traditional vision of a “water domain” founded on a separation of problems and cycles (small/large) on one hand and “professions” (drinking water, sewage and evacuation, hydrology, fluvial, maritime, groundwater...) on the other hand seems to fade away, leaving the room for unification/integration of all of this into a coherent unity.

Society over recent decades has become much more aware of the threatened sustainability of "the second economy" which we commonly call the "natural environment". Most built infrastructures are considered as interferences in the environment and their impacts must be correspondingly minimised and, if possible, made controllable. This trend is supported in more recent times by the long-ongoing discussion on climate change. The water world, especially, has become much more sensitive to and aware of these issues. A new awareness of the notion of “environmental footprints” introduced itself in the society.

Awareness and sensitivity in a society which is becoming more open, transparent and communicative, has been multiplied by modern developments of the ICT. The Internet is accessible nearly everywhere at any time providing Web-services for communication, information and sharing on documents, pictures, music and videos. Because of ease of access to and variety of information and views the citizens in a post-modern condition of society (commonly associated with what the European Union Lisbon agenda likes to call an

'information society') have become more curious and active, and even proactive about upcoming changes and the consequences of these for their futures, and even for their lives. Politically-oriented developments within societies that are, ostensibly at least, directed towards more educated and more engaged citizens, have led to more individuals and public interest groups who want to understand what is happening within their environments: what is being planned on the local or global political level and why this should be good and beneficial to them. Groups want to be heard and to participate in decision making processes: they want to be involved in matters about which they care and communicate. It is essential, however, that they clearly understand if and which are the ***objective constraints*** related to physical laws or political/economic reasons and that whatever is done or wished ***is the subject*** to these constraints. The technical means for communication and information necessary to these ends are at hand. ICTs have dramatically changed whole economies and societies, system components are becoming smaller and increasingly network-orientated and mobile and the flexibility of software is opening new dimensions. "Information-sharing" and "Cooperation" between citizens and stakeholders, consultants, authorities and lawmakers have become a central and feasible issue of the day.

Professional engineering and business are unthinkable today without the evolution of the Internet and mobile devices meanwhile representing the dominant infrastructure of ICT. Networking-embedded systems and networking services are offering new perspectives in nearly all fields from engineering to households; they are pushing developments in all areas, representing an enormous business market which will also reflect mentally on societal developments.

In view of these societal and technological changes, all of what is called "water sector" activities (including all activities and aspects of use, management, legislation and directives, protection and political decisions concerning water) is being completely transformed and modified. These transformations are founded on three pillars:

(i) Dealing with water problems on different scales of structures and the integration in face of foreseen scarcity, generalised pollution, climate change and the growth of mega-cities.

(ii) Change in the composition of decision making bodies: instead of engineers only, a whole new entity composed of stakeholders including the general population, elected bodies, NGOs, the media etc. is now evolving.

(iii) Penetration of all activities, structures, behaviour and reflexes of the whole water industry and indeed of all concerned groups and individuals by ICT, Internet and mobile communication networks.

It is in this context that the ***definition of HydroInformatics*** as collection (including data surveys, etc.), creation (including modelling), interpretation (including integration of various domains inputs), communication (including projection of the results and impacts towards large public) and management (including aid in participation of decision makers) of information concerning water sector activities should be used. This is new and to underscore this evolution the Working Group proposes to use from now onwards the term HydroInformatics (with capital I) rather than traditional one of Hydroinformatics. Indeed, HydroInformatics, for becoming an accepted player in these fields, has to change mentality and views; it has to implement techniques and methods from ICT and information science to collaborate intensively with other disciplines, not only on the technical level. Only in this way can relevant aspects of socio-economics, law and regulations, culture and traditions as well as workflow, psychology, information policies and media be integrated into ‘system’ approaches. Such systems will change the working situation of engineers, their education objectives, create job opportunities and influence societies; they will support decision making in collaboration with the public showing benefit and risk to involved citizens and stakeholders and help generating consensus.

HI takes and will take advantage of the general progresses of ICT (hard and soft), as all human activities do. Clearly, the increase of CPU power (massive parallel computing, cloud computing, etc.) extends the possibilities of our numerical models, and of 3-D displays; clearly Web 2.x opens the access to our information to millions of new users; and the new products in the fields of micro-sensors, alternative power supply, wireless telecoms, revolutionise the whole domain of real-time monitoring and, consequently real-time management. But the evolution in HI is finally driven, not by these techno-progresses, but by the growing

awareness that, even if modelling is historically the centre of HI, it should be connected-interwoven with all the various aspects-businesses of the Water- Environment domain.
Viewed like that HI is the template to business process approach of all projects as well as implementation of management systems within water sector.[2]

5. HydroInformatics and its main areas of interest and activities against the background

5.1 Informatics and Information in the Water Sector

"HydroInformatics" comprehends all information technologies, methods, models, processes and systems applied in the "water-sector" and water-issues related neighbouring fields. Information is understood in an abstract sense; it may be about physics, environment, economy, social issues, organisation, law, regulations and more. Models and processes concern physics, business, workflow, communication, management and more again. Thus HydroInformatics applies, generates, models, manages, transforms, condenses and archives information concerning the "water-sector".

Traditionally HydroInformatics has been focused on the numerical simulation of physical processes in so-called "models". This limitation is too narrow. The term model has to be widened up to any kind of *information to be modelled* in the water sector. As information combines data, methods, syntax and semantic, any simulation model is just a piece of information in the same manner as an engineering report, a digital elevation model (DEM), a water level monitoring application, an operational plan of a treatment plant or a workflow map.

Activities in the water sector are oriented towards building, managing and operating water-related infrastructure and utilities as well as towards observation/understanding/ management of hydro environment for providing water, for improving its quality, for managing its quantity and for protecting against damages in view of sustainability and climate change. The activities are embedded in the objectives of a sustainable socio-economic development of society and communication processes between citizens, stakeholders, companies and politicians.

We are at a time when the influence of modelling is growing rapidly. Models of complex physical and human behaviour are coming into routine use. Ordinary, everyday devices contain inbuilt processors running embedded models. We barely notice the insidious spread of models into our lives. HydroInformatics community should be leading the way by embracing and promoting many and varied uses of models in water and environmental management and engineering.

Besides techniques and methods directed towards the description and functioning of systems, models remain the core technological elements of HydroInformatics, but have to be understood, however, in a wider than traditional sense. Traditionally they described the physics of flow and transport and its interaction with other aspects such as the growth and decay of species, habitats and populations, and then in terms of quality and quantity. These models interact with further models about socio-economic and societal developments of regions, generating a nonlinearly interacting system of models of whatever is supposed to constitute "the real world".

Projects, infrastructure and the business of organisational units have to be managed and coordinated. Strategies for workflow and for running processes of technical, business, financial and communication systems have to be designed for in-house and public and political environments. The transformation and interfacing of information from various fields has to be modelled by descriptions and methods which support their

[2] A **business process** or **business method** is a collection of related, structured activities or tasks that produce a specific service or product (serve a particular goal) for a particular customer or customers. Business Processes can be modeled through a large number of methods and techniques.

implementation in digital form. To create tools and methods allowing all water sector stakeholders to conceive and interweave (if not normalise) integrated and coherent Information Systems is no doubt the future.

Models of physics and organisational processes might be seen just as generators of information providing raw data from diverse application fields. In "HydroInformatics" this information has to be cultivated according to the pragmatics for which it has been produced. It has to be processed and adapted to the needs and objectives of the water sector. Important aspects are of course the diverse nature of interacting simulation models of physics, environments, societies, economies and organisations.

Models, however, are not the only aspects: information, be it raw from observation or from simulation, has to be transformed in such a way as to be communicated in a transparent manner to professionals, politicians and citizens for decision making and consensual understanding. Moreover, "models" are not necessarily in the form of software; they may be also be intellectual concepts which, if they concern the water sector and if they ask for informatics to be forwarded, must be put into action or disseminated within the HydroInformatics domain.

HydroInformatics domain, activity or movement embraces the full range of what is commonly called *business models*[3] from public open-source developments through to private commercial developments, without bias towards any particular business model.

Some explicit examples of the subjects that HydroInformatics is related to and with which close interactivity, already existing, will develop tremendously:

(i) Major role played by GIS as system structuring all information, as pivotal point of integrated Information System. Note that GIS as specific tool fades away, becomes a part of other bases like ORACLE Spatial.
(ii) Real time problems: sensors, SCADA, Real Time databases, related telecom systems;
(iii) Tools of operational management (work management systems), of the maintenance and of asset Management.

Whenever water related problems, or, more widely, the environmental questions are concerned , there is **continuity** in the background of all of the activities that follow. Typically in most situations there is an initial "problem" stemming from engineering needs, from political or investment projects, etc. Then one tries to find "solutions" that are nothing else but elements leading to or aiding the decisions. This logical chain from "generating fact" to the solution-decision goes across a number of "businesses" or "stakeholders" and must be repeatable at any time. So it is obviously highly desirable to maintain strong consistency in concepts, data, and information along this chain. Such is not necessarily the case but precisely this is a major point for HydroInformatics because it is its "natural role" to ensure such consistency, mainly by conservation of **uniqueness** of data and information. When one considers the chain beginning with projects conceived by, say, administration or politicians and continuing through design, impact studies, decision to implement, construction and operation there is a need for guidelines ensuring the consistency. HydroInformatics can supply means and ways to elaborate such guidelines for various types of activities related to water sector.

5.2 Research and Science

The sustainable development of the water sector comes down, in implementation and praxis, to engineering tasks and thus "HydroInformatics" must be seen as an engineering discipline. In this sense,

[3] A **business model** describes the rationale of how an organization creates, delivers, and captures *value* - economic, social, or other forms of value. The process of business model design is part of business strategy.

In theory and practice the term business model is used for a broad range of informal and formal descriptions to represent core aspects of a business, including purpose, offerings, strategies, infrastructure, organizational structures, trading practices, and operational processes and policies. Hence, it gives a complete picture of an organization from high-level perspective.

"HydroInformatics" has its own research objectives which aim at the foundation and promotion of the water sector in all its aspects.

In short, research in HI domain might be summarised, albeit very unconventionally, under the term: "information and its model building". This may be understood in the sense of structuring information about physical and organisational processes. New techniques have to be developed, new methods designed, the range of validity and performance investigated and models be interfaced by a standardisation of procedures and data. Innovative concepts about geometrical representation and information-defined objects using by modern ICT must be investigated, with virtual communication and collaboration processes considered with *emphasis on non-engineering clients*, such as partners, as well as processes for education and promoting understanding in decision making. Integrated processes reflected in HI tools, which are sufficiently interconnected, may open new request and necessities for further applied research, basically in the bottle necks of existing technologies (such as new features in graphical tools, much faster computational engines, wireless nets and mobility etc.).

5.3 Education and Life Long Learning

HydroInformatics aims at the education of staff to do these kinds of jobs; such persons might even be seen as "information managers and advisors". Their profile is not one that is supposed to "manage" people or organisations: they are supposed to manage information within the complex areas of the water sector and to that end they must be knowledgeable in specific domains of this area. They must be knowledgeable enough to understand the constraints, difficulties, limitations and possibilities of these domains in order to be able to coordinate the information coming from each such domain and to organise the feedbacks and interactions that will be beneficial to the further development of both.

These persons must have a sufficient knowledge about water and environmental processes to run and validate the corresponding models; they must understand the processes that are mapped in the related models; they must be able to condense and interface information; they must be able to organise workflow and information processes; they must be able to manage documentation and presentation; they must be able to make information transparent so as to advice decision makers and communicate with the public. *Social skills* in collaborating with people of different professional and cultural backgrounds are needed. To optimise this whole they must be able to make information and findings flow in interactive ways from one domain to another so that the knowledge, the progress, the innovations and the applications in a domain can be improved thanks to information coming from other domains.

This profile demands knowledge about the physics of water in hydraulics, hydrology and the environment, about mathematics and computational methods, about information modelling and communication as well as about the supportive means of ICT. Complementary to these are methods of geometrical modelling, presentation, documentation and a spectrum of selected topics from computer and social science, economy and psychology, the latter supporting the skills necessary for a multicultural interdisciplinary collaboration in an international, sometimes virtual, environment. Those concerned should have a minimum of culture in civil engineering because of its central role in project implementation but also in water/environmental legislation as well as in geography and cartography. The education should be "hands on" with models of all kind. The process of taking responsibilities should be inculcated through training by internships in companies. The outcome of such curricula should be an engineer who can support consensual views and actions of decision makers and users, on the one hand, and executive professionals and engineers, on the other hand, with respect to science, engineering and social environments. The engineer should be able to maintain this qualification life-long by corresponding learning periods.

This leads to an intensive demand for HydroInformatics educated engineers, managers and, above all, leaders in public services and in the private sector in a rapidly changing society.

5.4 Universities, Research and Professions

Universities are changing in modern times with the transition towards an "information society", under the "Bologna Declaration" and as mass education institutions. They are reacting to their new role by introducing new profiles and grades of professionalism. In Europe the "Bachelor" is seen as a first profession qualification degree while the "Master" has become the second degree that may or may not be sought by the future professionals, whether praxis or research-oriented. The "Dr.-Thesis" is a grade awarded at the end of a system of corresponding courses and a research project that in many cases is trivial or formal; in most cases it has nothing common with requirements of new contribution to the field as it used to be until the middle of second part of 20th century. This requires universities to react correspondingly in terms of numbers and qualifications and this requires a clear profile and definition of "HydroInformatics education". At present, the profile is pretty vague and differs from place to place. Therefore, due to the international character of HydroInformatics and in order to guarantee as much as possible the sanity of the Profession some standards concerning the educational profile are needed. The Universities in the short term (some 10-15 years) should "standardise" their ideas about what is an objective and professional "HydroInformatics" profile. Without this the Profession cannot interact or provide feedback to the University and the University cannot satisfy the needs of the Profession. Today's most common idea on both sides is that "HydroInformatics = modelling and/or GIS and/or programming, etc. etc." and that is clearly not sufficient.

Standards cannot be imposed formally: they have to be developed by Academia in collaboration with the Profession and its Praxis. If there is a known curriculum framework and if the Water Sector professions recognise in practice the minimum content of this curriculum, such as is necessary to be called a "HydroInformatics diploma", then the profile of "HydroInformatician" will need to be clearly defined and founded. Note that, following Bologna agreement the fundamental change of concept concerning doctor's degree opens the way to better specification of HydroInformatics curricula in the sense that it gives 3 years more for specialised studies that replace original research required in time for Dr. degree.

Currently the link between the research and practice is weak and the time necessary to transfer the R&D results towards practice is shockingly long if one compares it with ICT domain. To improve the situation there is a need to open existing HydroInformatics community to (or even more: to create larger HI community inclusive of) engineering consultants that do the bulk of water-related engineering as well as to the water systems management companies and institutions (specifically urban water utilities).

5.5 And the IAHR/IWA Committee

It should be remembered that the present document is elaborated by a Working Group of the joint IAHR/IWA Committee and both IAHR and IWA have an obvious role in the future of HydroInformatics. This role should be experienced through a number of activities:

- The research within the aquatic domain in areas such as modelling, measuring, surveying and computational hydraulics is traditional within the IAHR/IWA membership. However, the task to promote the links between this research and the requirements, quests and problems coming from Water Sector through HydroInformatics should be better understood and carried out within all concerned groups.
- University Education: IAHR, by its very composition of a majority of university researchers and teachers should proactively participate in the "Universities and Profession" activities described above.
- Within the Water Sector many HydroInformatics activities have been implemented and created (e.g. within IWA, but this is only an example). It should be the IAHR's role to try to bridge the relational gaps between these groups and institutions by offering them what the IAHR in this domain has been developed during the last decades.

The above points can be considered as the tasks for the HI Committee.

6. HydroInformatics - Quo vadis? What to do?

There are two aspects of the future that are concerned in our present initiative. One is objective: whatever we wish, whatever we do, what is going to happen within next, say, 10-15 years; another one is subjective: what we wish, what we can do, what we shall try to do during this period.

(i) What is going to happen? It seems clear today that the whole water sector is going to be completely penetrated by ICT and Internet-like technologies. All this may lead in a more or less distant future to the unification and possibly the standardisation of management of information within areas of water industry. The things will converge towards the concept of "smart water networking" including of course projects and implementation of works in coastal areas and river basins, for food and agriculture, for industrial use, energy production and biogas, for drinking and waste processing. Nevertheless it is very likely that the driving force towards this will be urban water management and utilities. This is so because the population needs today are greatest in this area, because most of human population is going to be regrouped in the megacities, because this area is today very far behind the sophistication of ICT tools used in other water domains (e.g. numerical modelling) and, hence, the gradient of implemented innovative applications will be the steepest. Quite obviously all other domains will join in the run and the driving forces will come from the ICT industry, not from the hydraulic research, because the former produces industrially applicable**,** often off-the-shelf systems and devices that may modify the whole systemic approach while the latter can only produced embeddable tools like 4th generation modelling software. Because of the importance of the water these developments will very quickly penetrate the domain of decision making, i.e. politics, financing of investments, social sciences, information & communication with citizens etc. On the other side of the spectrum they will most likely completely modify current (traditional) way of working of consulting and also the relationship between the applications/industry (including consulting and contractors) and university research on the field of hydraulics, hydrology and water management:

- It is ***very*** likely that today's market of the modelling software will decline and possibly fade away. It may well be replaced by "Modelling Software and Expertise as a Service". All recent developments of "Software as a Service", "Infrastructure as a Service", "Development as a Service" that so far have been limited to the area of computer and informatics applications will no doubt overflow into the water domain within next couple of years. Already most of applications we use on our laptops are stored somewhere in the cyberspace. And "cloud computing" will help it.
- This will lead to a pressure from "modelling software & expertise" business on the water-oriented research to go beyond today's limitations in mathematical theory computational hydraulics and computational fluid dynamics. Same will happen to physics, e.g. sedimentation theories. This will also lead to a pressure on the university education and curricula. Indeed, such enormous, revolutionary changes will ask for different ***technical leadership*** within the structures of water sector industry, i.e. for different generation of engineers. Given minimal 5 years cycle of engineering education, given the delay necessary to the education institutions to adapt themselves (at least another 5 or 10 years) there will be enormous push, coming from the needs of industry, towards LLL and postgraduate specialisation in specific courses and institutions.
- Networking-embedded systems and networking services are offering new perspectives in nearly all fields of technological infrastructure from engineering to households; they are pushing developments in all areas, representing an enormous business market. This also holds for the field of HydroInformatics. Integrated intelligent electronic nets of all components and services must be designed and operated for generation, management, distribution and billing

of fresh and waste water in cities, on the level of water-basins, for the management of floods and droughts beyond the regional level. But also the interlinking of water systems with other areas such as power generation, cooling and intermediate storage of energy under ever changing conditions has to be considered. Only through the use of such technologies the challenges put by global warming and climate change could possibly be faced in the future.

As an example of what would happen whatever we do consider the one of currently predominant business models: the sale or granting of in-perpetuity (generally 20 or 25 year) licenses to use software packages. We definitely see the demand for pay-by-use software and technology advances now supports this business model in a reasonable way. But we are already on the way towards Software as a Service becoming a regular business model for HydroInformatics. There are already few companies doing just this, the information confirmed by the comments from 1st and 2nd Circles of persons participating in elaboration of present Reports. It is clear that current "model" based on selling packages is changing and will not last in the future. What we do not know is what will replace it – there are a number of possibilities!

(ii) What we wish or can do? We, i.e. what we used to call up to now and typically within IAHR/IWA territory, the HydroInformatics Community? Assuming that what will happen at any rate within the near future was correctly described above, there are two possibilities: either we stay where we are and look on this new world from the top of our ivory towers; or we try to accompany the movement, to accelerate it as much as possible, to make some parts of it more coherent, take the leadership of our immediate neighbourhood towards integrating these changes. Incidentally it means of course to stretch our networks beyond IAHR trying, however, to keep intellectual leadership in order not to lose the experience and tradition gained during last 30 years of existence of our "IAHR HydroInformatics Community".

In this context, assuming that we chose the second way and that we can consider ourselves as leaders (among others) in the area, what should we do? ***"One may identify three skills that are necessary for leading strategically for long-term growth: understanding the operational environment, making clear decisions and involving others in the strategic process."***[4].

- Actually the most of the preceding paragraphs are devoted to "understanding the operational environment". The very attempt to describe (in a lengthy way) what we understand by "HydroInformatics", as well as the present situation in industry and education, is precisely that.

- "Making clear decisions". In our case it is first to state clearly the ambitions we have, and next the decisions of actions that we should take.

  Ambitions, even though we limit their extension to our domain of possible influence (that is rather limited…) are considerable. Namely, ***we wish to promote and maintain the name of HydroInformatics***. We wish to make it accepted as a domain, the essence of which is to coordinate the results and the contents of a number of various fields of knowledge (including some "soft science" fields); to facilitate interactive transfers of concepts and ways of thinking from one field to another; to help in the elaboration of decisions (projects, actions, and policies) based on synergetic considerations of the results of various fields; to pave feedback paths from social requirements, through HydroInformatics ways, tools and means, towards various fields while transferring concepts from one field to another in order to enrich them and to progress. Conceived as such HydroInformatics is enriching itself through the progress of other domains and directing them towards applications. HydroInformatics is itself a generator of innovations by the

[4] Taken from aa paper in Forbes Magazine but seems correct!

very fact of being a transversal approach that uses the progress of various disciplines. Our ambition is to push this concept through and participate in its development.

There would seem to be a role for the Hydroinformatics Community not only to adapt to improved ICT but also to propose, test and communicate changing business and delivery models. This can be done through exchanges of opinions, criticism, etc. Such exchanges imply some kind of permanent correspondence "platform" or "forum". New business models will be imposed by the market following ICT progress but the HI Community can help to discard what is not so good.

The actions we can take:

- To develop a wide (as wide as possible, ***within and outside*** of IAHR/IWA/IAHS) network of people and institutions interested and willing to participate in discussions, exchanges of view, of information.
- To influence the education (LLL, graduate, undergraduate), both the institutions and curricula in order to help the advent of new engineering leadership.
- To accompany, as individuals and members of institutions, of projects, of associations the "objective" developments and events as described above, trying to make those that are within our area as coherent and bold as possible.
- To use as a springboard to this the IAHR/IWA/IAHS HydroInformatics Committee, International Journal of HydroInformatics, HydroInformatics bi-annual conferences.

- "Involving others in the strategic process". This of course is the essence of leadership activity (as distinct from management). It actually is the way of implementing the actions enumerated above. Our Working Group activity is the first step. The further steps would follow stemming from our Report.We should take more of a coordination role by more actively making links with other organisations involved in the development of HydroInformatics. For example, there is considerable overlap between the activities of the integrated environmental modelling community and HydroInformatics. Because of this situation the HI Working Group will initiate, before the formal end of its activities, launching contacts with a number of organizations. The full Report will be sent to them and they will be asked to participate in setting up together some kind of the mailing-exchange list of addresses to contact. But then again it will be for the "HI community", with the IAHR/IWA/IAHS Committee as the basis, to organize and act.

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