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special issue on
Hydroinformatics

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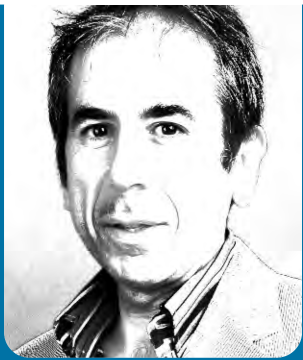
CAN INFORMATION TECHNOLOGY ASSIST US IN DISASTER HANDLING?

EDITORIAL BY PROF. MICHELE MOSSA



Prof. Michele Mossa
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The latest news reports of tropical cyclone Haiyan suggest a high death toll, with the Phillipines President indicating around 2,000 at the time of writing this editorial. It seems that tropical cyclone Haiyan which impacted the Philippines on November 7th 2013 may be the strongest tropical cyclone to make a landfall on record. The thirtieth named storm, thirteenth typhoon, and fifth super-typhoon of the 2013 Pacific typhoon season, Haiyan originated as an area of low pressure east-southeast of Pohnpei in the western Pacific Ocean on November 2. On November 6, with an expanding and deepening central dense overcast and clear eye visible on satellite, the Joint Typhoon Warning Center (JTWC) upgraded Haiyan to a super typhoon, that is a typhoon in which maximum sustained winds attain or exceed 240 km/h early.

The Philippines is the most-exposed large country in the world to tropical cyclones, and it has even affected settlement patterns in the northern islands.

Internet giant Google produced an interactive crisis map that I would like to report hereafter:

http://google.org/crisismap/2013-yolanda

It shows evacuation shelters, command posts and medical centres.

It is well-known that some processes can alter tide levels during storms, causing surges. Some of these processes are the pressure effect, the direct wind effect, the effect of the Earth's rotation, the effect of waves, and the rainfall effect. Particularly, the pressure effects of a tropical cyclone will cause the water level in the open ocean to rise in regions of low atmospheric pressure and fall in regions of high atmospheric pressure; in this way a tropical cyclone results in surge.

But why are hurricanes, these monster storms becoming even more monstrous? Generally the number of hurricanes waxes and wanes with a regular and natural cycle, but some scientists have identified that the strength and length of storms is probably affected by global warming. There is evidence that the number of storms each year is controlled, at least in part, by a natural 20 to 40-year cycle. For example, the number of hurricanes each year was less than usual from the mid-1960's to the mid-1990's, but since 1995 there have been typically more hurricanes than usual each year. This means we are currently in the phase of the cycle when there are more hurricanes than usual. Scientists predict that the number of storms will be higher than normal until about 2015. As global warming causes oceans to become warmer, and more moisture is held in the atmosphere, the intensity of hurricanes and the amount of rain they produce will likely increase. There is strong evidence that global warming has been increasing the intensity of hurricanes for over the past few decades.

In the past 30 to 50 years the oceans have warmed about 0.1 degrees Celsius. This may not seem like much of a temperature change, but it is quite significant. In fact, the oceans have an enormous heat capacity because of their large size, thus, it takes a great amount of heat to warm them. The fact that they have warmed significantly in 30 to 50 years is remarkable. And this change appears to be causing a remarkable change in the strength and length of hurricanes. Hurricanes take heat energy from the oceans and convert it into the energy of the storm; this means that the warmer oceans offer more heat energy to hurricanes and, finally, this makes them become stronger storms. According to MIT scientist Kerry Emmanuel, hurricanes have become 70-80% more powerful over this time.

As already written in other editorials, Hydraulic engineering mainly deals with the Earth system and we must expand our view to look both at processes affecting the whole Earth and how those processes influence our lives. The IAHR community can help in both developing better hydroinfomatic tools to help society evaluate different development scenarios and at the same time we can assist in providing tools to help in disaster handling. This is why the present issue of Hydrolink is devoted to Hydroinformatics. I would like to finish the present editorial, quoting Prof. H.J. Fernando's opinion of his interview published in Issue 3 of 2013 of Hydrolink: [We can address a correct future development of projects, considering the impact of climate change] by conducting downscaling exercises […] Perhaps, during such exercises, the safety margins can be unacceptable or uneconomical, when we will pay more attention to uncertainties. Then designs can be done using an adaptive management framework". Surely, on this point Hydroinformatics could help us, also considering prof. M. B. Abbott's words: "[Hydroinformatics] is a technology that itself draws upon, combines and co-ordinates a considerable amount and variety of quite other technologies, and even of some sciences. […] Hydroinformatics is thus a kind of 'technology of other technologies, and sciences' and so a kind of metatechnology'" [Abbott, M.B., "Introducing Hydroinformatics", Journal of Hydroinformatics, IWA Publishing, 01.1, 1999].

I hope you enjoy this issue.

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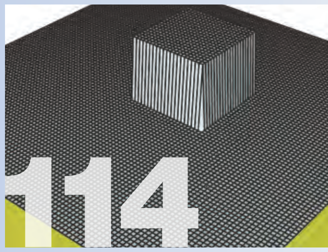

special issue on *Hydroinformatics*

5 QUESTIONS TO... Mike Abbot

INTERVIEWED BY DRAGAN SAVIC, GUEST EDITOR, CHAIR OF THE IAHR/IWA JOINT COMMITTEE ON HYDROINFORMATICS

Michael B. Abbott is Emeritus Professor at the UNESCO-IHE Institute for Water Education, Delft, the Netherlands, and a Director of the European Institute for Industrial Leadership in Brussels. He founded and developed the disciplines of Computational Hydraulics and Hydroinformatics and co-founded, the Journal of Hydroinformatics with Professor Roger Falconer. He also initiated the MIKE systems of the Danish Hydraulic Institute, his name being attached to these systems by the then-director, Torben Sørensen.

1. How do you see the evolution of Hydroinformatics since you first coined the term more than twenty years ago? Were you expecting such growth in this field?

Concerning how I see the evolution of Hydroinformatics since I first coined the term just over twenty years ago, I have observed an extraordinary scientific development, but then an equally extraordinarily increasing confinement to the 'box' of modern science, as this was established in the Condemnation of 1277 at the University of Paris, and which has since become the prison of almost all of our 'Western' manners of thinking. Given its Eurocentric foundation this was to be expected, and especially so in environments where there remains little or no teaching and reading of the philosophical foundations, let alone the spiritual grounds, of our existences: see Vojinovic and Abbott later in this publication.

The third volume of the third book of Karl Barth's Church Dogmatics describes this process of de-spiritualisation in detail. The 2012 IWA book of Zoran Vojinovic and myself, entitled Flood Risk and Social Justice, takes up these issues even as it establishes the more extensive grounds for the future of hydroinformatics, and especially its social and environmental dimensions. It provides a reassertion of 'hydroinformatics', bracketing the 21 years of endeavour that has followed after the Hydroinformatics of 1991.

2. Do you think Hydroinformatics has matured as a discipline?

Certainly Hydroinformatics has matured greatly as a discipline over the last years, and it has found many sound applications, and then not only in engineering but also within society generally. The 'down side' of this is that the social aspects still leave much to be desired and this is especially so in what "The West' so condescendingly describes as 'The Third World". The overcoming of this weakness necessitates new forms of working new kinds of praxes when entering into this 'Third World', as reinforced in a paper entitled “Towards a hydroinformatics praxis in the service of social justice” that should appear shortly in the Journal of Hydroinformatics (doi:10.2166/hydro.2013.198).

3. What are the biggest challenges faced by Hydroinformatics today?

Among the greatest challenges are those that are addressed in this upcoming paper. These are commonly challenged by jurisdictions and we have a professional responsibility correspondingly to fight for social justice, and then in the first place on the side of the poor and the oppressed among the stakeholders. The above-mentioned paper introduces how this can be realised in many cases through establishing stakeholder participations based upon arousing a greater awarenesses of the risks with which the threatened population is confronted, as introduced by highly realistic, dynamic and coloured illustrations of the consequences of proposed changes. This implies the creation of active stakeholder participations that lead into creative stakeholder actions.

4. How do you see Hydroinformatics contributing to the solution of the problems affecting global water security?

This is concomitant with the above in that challenges to water security most commonly have financial gains as their objectives, and therewith, as the Bible speaks:

"For the love of money is the root of all evil: which while some coveted after, they have erred from the faith, and pierced themselves through with many sorrows."

I Timothy 6: 8-10, King James Version (KJV).

5. Where do you expect Hydroinformatics to be twenty years from now?

A very naughty reply is: "In China!". Given the appalling lack of teachings and understandings of philosophy and theology in the English-speaking world generally, some further shift in participating nationalities seems unavoidable, and indeed this is already showing itself as the Journal of Hydroinformatics becomes ever more populated by non-English-speaking authors.

A SHORT STORY OF HIGH PERFO COMPUTING IN THE TELEMAC INFORMATICS SYSTEM

BY JEAN-MICHEL HERVOUET AND CHARLES MOULINEC

Jean-Michel Hervouet: **Laboratoire National d'Hydraulique et Environnement, EDF R&D, France**

Charles Moulinec: **Science and Technology Facilities Council (STFC), Daresbury Laboratory, United Kingdom**

We like to say that one of our applications: the computation of the Malpasset dam break flood wave, required one day of CPU time in 1993 to compute 1 hour event. It only takes 4 seconds now in 2013. Yet you will still hear users claiming that their simulation lasts one day or more. This is no surprise, the Malpasset finite element mesh had 26000 elements, now meshes may have millions of elements, and, e.g. for morpho-dynamics, several years must be simulated. To sum up a situation that has been lasting since the early times of Computational Fluid Dynamics: the need for progress is never ending and further research is necessary. Let us add that both statements are generally suspiciously received by management and decision makers.

Boosting Computational Efficiency

If we try to find out what was really instrumental in boosting computational efficiency in the last 20 years, we see that the progress in numerical schemes and algorithms cannot be neglected, and that it contributed a factor 20 or 30 to the speed-up. However you do not find every year or two a way to go twice as fast (or, do you?) and the real outstanding revolution which comes to mind is called: "Parallelism with domain decomposition". To tell the truth, and to start from the beginning, we must admit that we did everything to avoid this technique. The keyword in the 80s was "vectorisation", which was for computers what "Taylorism" was for cars: in a long loop of sums of numbers you would wait for one clock period only before starting a new sum, instead of waiting for the completion of the previous sum. This is where we discovered that the computer, or the compiler, had to be helped and we started to play with new concepts, such as "backward dependency". A new and very heuristic numbering algorithm for points in a mesh eventually did the job: Telemac got a speed-up of about 10 on vector computers like Cray-XMP. Though we had to reorganise a few subroutines and learn a bit of computer archi-tecture, this was not too painful. But then came the new generation of computers which gave us higher hope: parallel machines. At first it looked marvellous; the compiler seemed to do the entire job: splitting and distributing your many loops of sums, divisions, and so on, among many processors. This was called "fine grain parallelism". It was in the 90s, but a few European projects later the conclusion was disappointing: the speed-up to be expected with our applications was about 2, whatever the number of processors was. The grain was too fine… and we began to hear voices saying: "the only solution is domain decomposition". Every processor would solve your problem on a part of your computational domain. This was actually very bad news, now we had to do the work ourselves! The task seemed overwhelming: just think of telling 100 processors how to solve together a single linear system, then imagine particle tracking, with particles jumping from one sub-domain to the other… a nightmare! The first breakthrough came from Germany in 1997, with the PhD work of Reinhardt Hinkelmann, from the "Institut für Strömungs-mechanik und Electronik, Rechnen im Bauwesen" in Hannover University: Telemac-3D was parallelised with domain decomposition! Not the simplest task to start with but much welcome. A few algorithms had been left over for "further research", e.g. and not surprisingly, particle tracking and the method of characteristics. However the proof was there: we could do it (after 3 years of hard work, though…). It was now just a matter of extending the principle to the whole system, and to tackle the algorithms that still resisted. We were not aware at that time that it would take about 15 years to complete the job, that domain decomposition would double the development time of any algorithm and that it would lead us to change our way of thinking. Like the green anthem, we had to "think globally and act locally". As a matter of fact, there is no master, every processor runs the same general program on its own sub-domain, and, thanks to few communications, the result is a solution of the whole problem, something like the behaviour of a flock of birds or a company of fish.
The performance was fairly good, for example a speed-up of 3.73 was observed on a Cray T3E

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running on 4 processors, or even stunning: a speed-up of 13.9 on 8 processors of an Origin 2400. This latter result found an explanation with the computer architecture and the details of the cash memory size. Year after year, parallelism was more and more used and its field of applications enlarged. In 2006 Jacek Jankowski, at Bundesanstalt für Wasserbau in Germany, managed to find an algorithm efficiently dealing with particle tracking, thus enabling the method of characteristics to be used in parallel. It gradually became obvious that for very large domains, there was no loss of speed-up up for large numbers of processors. Massively parallel machines opened the way to large computational domains, with e.g. more than 10 million elements. The new game practiced at Daresbury Laboratory consists of trying to get the best of High Performance Computing on huge simulations with 10000 or even more processors, and finding out what cracks down first: mesh generators, domain decomposers, CFD programs, post-processors, storage capacity? On the way Telemac-3D qualified for a Gold Award Incentive on HPCx (UK Supercomputer). The challenge was to get a speed-up of more than 1.7 when going from 512 to 1024 processors, we did 1.75. The current record for running Telemac-2D is for a simulation in the Gironde with a 200 million element mesh on 32768 processors of an IBM Blue Gene/P at Argonne US National laboratory. This systematic research also lead to strange discoveries: rare but amazingly unexplained crashes after hundreds of thousands of time steps were due to addition non-associativity in computers. Namely for a computer (a+b)+c is not equal to a+(b+c) for real or double precision numbers (floating point numbers) and in the domain decomposition world it can drive mad well-known techniques relying on dot products, like the conjugate gradient method for instance, unless you take good care of.
A posteriori, when all such problems were cleared up, it appeared that domain decomposition had a structuring effect on the way of programming: uselessly complicated procedures, ill-established concepts inevitably collapse under the strict and demanding rules of parallelism. Another surprise is that an amazingly small number of parallel functions are necessary for most algorithms, and they are provided by the message passing languages, such as PVM in the earlier times and mostly MPI now.

Actual Situation

What is the situation today? Version 6.3 of Telemac has been released in summer 2013. All new features, e.g. automatic tidal boundary conditions, a new module for algae moving in the current and a brand new oil spill model that combines Eulerian and Lagrangian approaches, are readily provided with parallelism enabled. At the Laboratoire National d'Hydraulique et Environnement (LNHE, EDF R&D), parallelism with domain decomposition on large finite element meshes is daily common practice for a number of studies: thermal plumes, morphodynamics in rivers and estuaries, renewable energy and farms of marine turbines. As the code is open for specific purposes and allows user implementation, this requires a basic training to explain that genuine questions such as "where is my point number 3541?" must now be thought differently and in a more invariant way…

More Research is Necessary

Is it the end of the story? The answer is definitely "No. More research is necessary!" After years of tracking nagging bugs, we are now convinced that the situation will be satisfactory only when all runs, be it in scalar or parallel mode, will give exactly the same results on a given application, and by "same results" we mean the same double precision digits in all results. We do not even want truncation error differences. This is the next challenge and then we will get a proof that there is no bug left, at least due to parallelism. This goal has already been reached in 2012 for particle tracking, paradoxically the algorithm that seemed to raise the greatest difficulties. One identified obstacle is the already mentioned a+(b+c) problem that plagues the finite element assembly and the dot product. There are already ideas available, like locally resorting to integer arithmetic. Shall we meet again in 2 years time for Season 2 of the story? One thing is sure, domain decomposition is so powerful that it is here to stay.

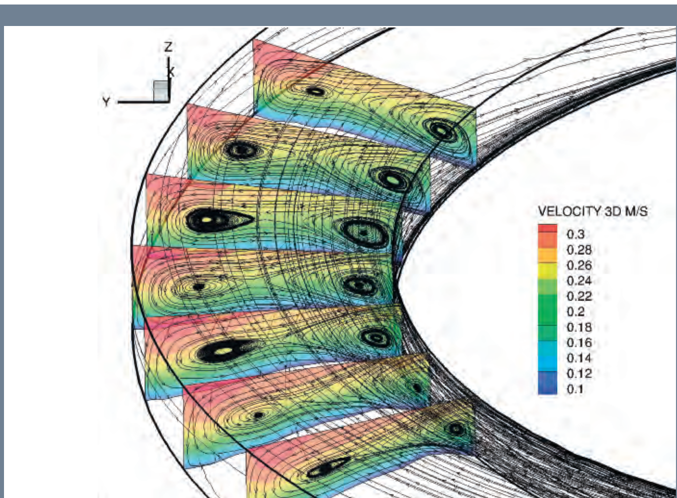


Figure 1: A typical study performed in parallel with Telemac-3D: computation of secondary currents in a bend. Courtesy of Dongchen Wang, trainee at LNHE

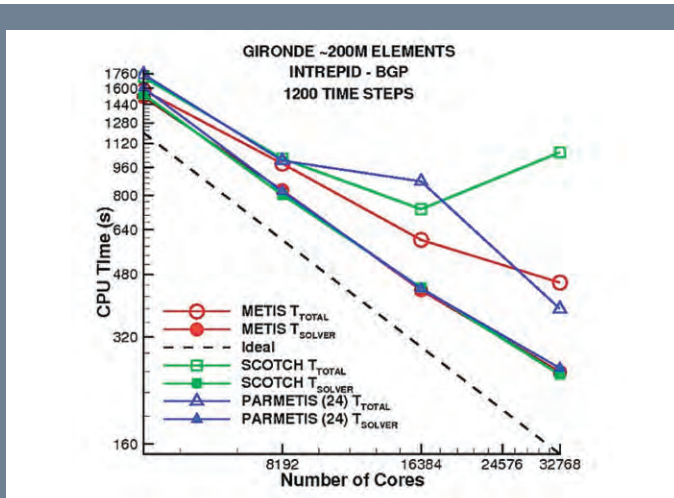


Figure 2: current research at Daresbury Laboratory: influence of mesh decomposition tools on speed-up, for very large meshes, here 200 M elements and 32768 cores. This research used resources of the Argonne Leadership Computing Facility at Argonne National Laboratory, supported by the Office of Science of the U.S. Department of Energy under contract DE-AC02-06CH11357

special issue on
Hydroinformatics

THE MOBILE TRACKER

Figure 1.
Mobile Tracker
measuring a water level

BY PETER-JULES VAN OVERLOOP AND MEINTE VIERSTRA

Every year water districts can save a fortune by making measurements from the field more cost-efficient. Field measurements are often still jotted down in a notebook, only to be manually processed at the end of the week. These measurements are then sent to the boss, who archives them. This whole procedure can be reduced to one click using the Mobile Tracker.

Introduction

Water boards are responsible for managing the water in their area. To do this, they must know the behavior of their catchment very well. The most direct way of doing this is through measurements. Measurements are also necessary to calibrate physically based, numerical models, to better understand the water systems and forecast extreme scenarios. A third reason why water boards take measurements is to satisfy agreements with neighboring water districts. Finally, these field measurements are used for the operational managements of pumps and gates. It can thus be said that measurements are the heartbeat of water management.

Measuring Automatically

Many water quantity variables are currently automatically measured and sent to a central database. The costs for such automatic measuring apparatus have declined in recent years, which is why the number of measurement spots is still increasing. Rising management and maintenance costs will, however, lead to a saturation point in the number of automatic measurement apparatus: Wear and tear from outside weather, dirt from organisms in the water, animals and vandalism are only a few of the reasons for which the apparatus frequently needs to be replaced and maintained. Measurements that are done by hand are much less susceptible to such wear, and will thus in many instances remain an attractive measurement method in several locations in the area. An additional benefit is that water district employees continue to operate in the field, and thus can identify problems which are not noticed by automatic apparatus.

Manual Measurements

The problem with manual measurements is that these are less accurate than automatic measurements and often cannot be completely reproduced. The first problem primarily has to do with entering data manually, while the second problem is caused by different colleagues in the field taking measurements in different ways such as rounding up differently, incorrect use of measurement apparatus or an inability to see the readings. The recent, “Gage Repeatability & Reproducibility” [Tennant 2001] field experiment conducted at a water district in The Netherlands revealed how substantial these mistakes can be.

Table 1. Results from measurement experiments using different measurement tools or methods by experienced field operators.

	Standard deviation (mm)			
	R&R experiment 1	Uploading experiment 2	Total	95% significance
tape measure	4.7	9	10	20
measuring stick	8.1	9	12	24
staff gauge	2.0	9	9	18

Figure 2. Mobile Tracker measuring a gate position (on the left is the original photo, on the right the manipulated photo with the perspective correction and how the angle resulting in the gate position is determined)

Figure 3. Mobile Tracker measuring a ground water level

Inaccuracies caused by manual data entry were also researched. The first experiment revealed how inaccurate measurement data was when read from measurement tools in the field. The second experiment revealed the inaccuracies in jotting down and analyzing the measurements taken. The results from these two experiments together revealed the total inaccuracies from the field data.

The data used in the gage R&R experiment was taken from three experienced operators on three different locations that used three different measurement tools: tape measure, measuring stick, and local staff gauge fixed to the embankment.

This gage R&R experiment determined the standard deviation of the different measurement tools. The tape measure has a standard deviation of 4.7 mm. This means that the measurement value taken from the tape measure is (with 95% significance) within 9 mm (double the standard deviation) of the true measure. For the other measurement tools (measuring staff and staff gauge this is respectively 16 mm and 4 mm.

The second experiment, whereby the measurement values are manually entered in a laptop and later in a central system led to a further 9 millimeters of standard deviation (thus a 95% significance of the true reading being almost 18 millimeters different from the one uploaded). This second experiment was done using 1000 measurement readings. The total inaccuracies can be determined by, per experiment, adding up the squared values and taking the square root of this summation. These results are shown in Table 1. It can thus be said with 95% significance that the uploaded reading is within 20 millimeters of the true measurement.

Peter-Jules Van Overloop is a scientist and entrepreneur in the field of operational water management with a broad experience in modeling and control of river, urban and rural water systems. He has written over 40 international and national publications and has presently a part-time position as Associate Professor at the Delft University of Technology. He is also founder and CEO of the spin-off company Mobile Canal Control.

Meinte Vierstra is a civil engineer specialized in water resources engineering & management. He is co-founder of the Delft University of Technology spin-off Mobile Canal Control of which he is managing director.

Real-time Measurements

Another difficulty with manual measurements is that these are noted down and are only later added to a database for further use. As a result, these data are not a reflection of the actual state of the water system, and are thus not suitable as a basis upon which to take operational decisions. The measurements are often only available weeks after they were taken for further use and analysis. While there are currently several systems in use which make it possible to make the data directly available to a central unit, these all require manual uploading of the measurements.

A recent innovation called The Mobile Tracker (MT) can be seen as the next generation of semi-automatic measurement devices. MT is made for the smart phone and uses the telephone's camera and special pattern-recognition software [Shih 2010]. This technology makes manual data entry of water variables unnecessary.

Mobile Tracker

The Mobile Tracker works as follows: When a field operator arrives at a location, they take the smart-phone and start an application that makes contact with the central database. The application uses the GPS coordinates and angles of the smart phone to identify the location and store all the relevant data. For water level measurements these would usually be the reference level, subsidence of the staff gauge and known impairments of the staff gauge. For flow measurements these are, for example, width of the gate and calibration coefficient. For

ground water measurements it is the level of the top of the groundwater pipe. With one click on the app, a photo is taken and from the photo water variables such as water level, flow and groundwater level can be measured. These values are then sent to a database and saved including information pertaining to location with a time check, the field operator on duty, GPS coordinates and camera angles. The photo is also sent and saved with the other information. The advantage of this procedure is that is faster than manual data and no data errors can be made. Because the photo is saved, it can be referred to afterwards using the correct photo at the right place and at the right time to verify concerns about inaccurate readings or disputes about a presumed situation. The central system can be managed from FEWS [FEWS 2013]. The Mobile Tracker is also connected to WISKI [WISKI 2013]. Figure 1 to 3 indicate the measurement methods for water level, gate position/flow and ground water level.

Conclusion

The Mobile Tracker is an innovation that makes manual measurement of water variables significantly faster and reproducible. The procedure for taking measurements is as simple as taking a photo with a smart-phone. It can thus also be used by less experienced personnel. In exceptional circumstances it could even be used by farmers in remote areas or students passing a stream on their way to school. The only requirement is a smart-phone.

The Mobile Tracker is currently being tested at different water districts in The Netherlands. The initial results have shown an accuracy of less than 10mm.

References

Tennant, G., 'SIX SIGMA: SPC and TQM in Manufacturing and Services', Gower Publishing Ltd., 2001.

FEWS, http://www.deltares.nl/nl/software/479962/delft-fews

WISKI, http://www.kisters.net/wiski.html

Shih, F. Y., 'Image processing and pattern recognition, Fundamentals and techniques', John Wiley & Sons, Inc., New Jersey, 2010.

AGE OF INTELLIGENT METERING AND BIG DATA: HYDROINFORMATICS CHALLENGES AND OPPORTUNITIES

BY RODNEY A. STEWART, DAMIEN GIURCO AND CARA BEAL

Rodney Stewart **is Director of the Centre for Infrastructure Engineering & Management (CIEM) based at Griffith University, Queensland Australia. His research is focused on intelligent water metering, end use analysis, and 'big data' hydroinfomatics.**

Damien Giurco **is Research Director at the Institute for Sustainable Futures, University of Technology, Sydney. His research studies the role of intelligent metering and efficient practices in the future urban water landscape.**

Cara Beal **is a research fellow at the Smart Water Research Centre, Griffith University, Queensland, Australia. Her research is focused on integrated water management, water efficiency and conservation, intelligent water metering and residential water end use studies.**

We are at the dawn of a new era of widespread intelligent water metering delivering live consumption data to utilities and consumers in developed nations. As with most new technologies, intelligent metering will follow a type of hype cycle, where initial excitement and great expectation on its benefits is weighed down by disappointment and disillusionment from early adoptions and then strategic enlightenment will prevail and ultimately productive strategic implementation. Fortunately, the conservative nature of the water industry and the challenges of intelligent metering implementation have meant that the excitement never reached fever pitch and the sensible path to strategic enlightenment is being progressed, albeit very slowly. While the large multi-national metering and software companies have created a range of products and software systems for utilities to automatically collect, store and present reports on customer and citywide water consumption data, a plethora of informatics challenges urgently need to be addressed by researchers, engineers, planners and computer scientists to yield the numerous claimed urban water planning, engineering and management opportunities that can be extracted from this big data revolution. If the call to arms to address such challenges can be realised, significant opportunities will surface including water loss reductions, real-time design optimisation of water networks, live online water use tracking and billing, heightened customer satisfaction with the water utility sector, to name a few.

Introduction

A range of external factors have placed an increasing onus on water utilities to adopt more sustainable approaches to urban water management as the era of readily accessible and inexpensive water fades. Covering costs, monitoring non-revenue water and meeting customer demands for equity in billing in the face of rising water prices are some of the core challenges. Recognising that intelligent metering has the potential to revolutionise current utility operations and customer engagement approaches, this paper provides a summary of the key informatics challenges for researchers and industry practitioners to ensure that this technology fosters enhanced urban water management.

To date, roll-outs of intelligent metering have been driven by the desire to reduce manual readings, increase data on time of use, leakage management, and end-use measurement (e.g.

shower, toilet, etc.). Technology development in the water sector generally lags that seen in the electricity sector. In the coming decade, the deployment of intelligent water metering will transition from being predominantly pilot or trial studies to mainstream citywide implementation. Citywide intelligent metering implementations have the potential to stream gigabytes of time stamped water use and other associated information (e.g. water temperature, pressure, quality) from pipe networks right down to the individual water use appliances (e.g. washing machine) and fixtures (e.g. tap). Such datasets are powerful for a range of water planning, engineering and customer response decisions but only if processed, refined and reported in a way that is more intuitive and informative than traditional approaches.

This paper firstly provides a brief overview of intelligent metering and some of the key drivers and barriers to its widespread implementation. A more focused discussion on the benefits that can be derived from intelligent metering and the hydroinformatics challenges is then provided.

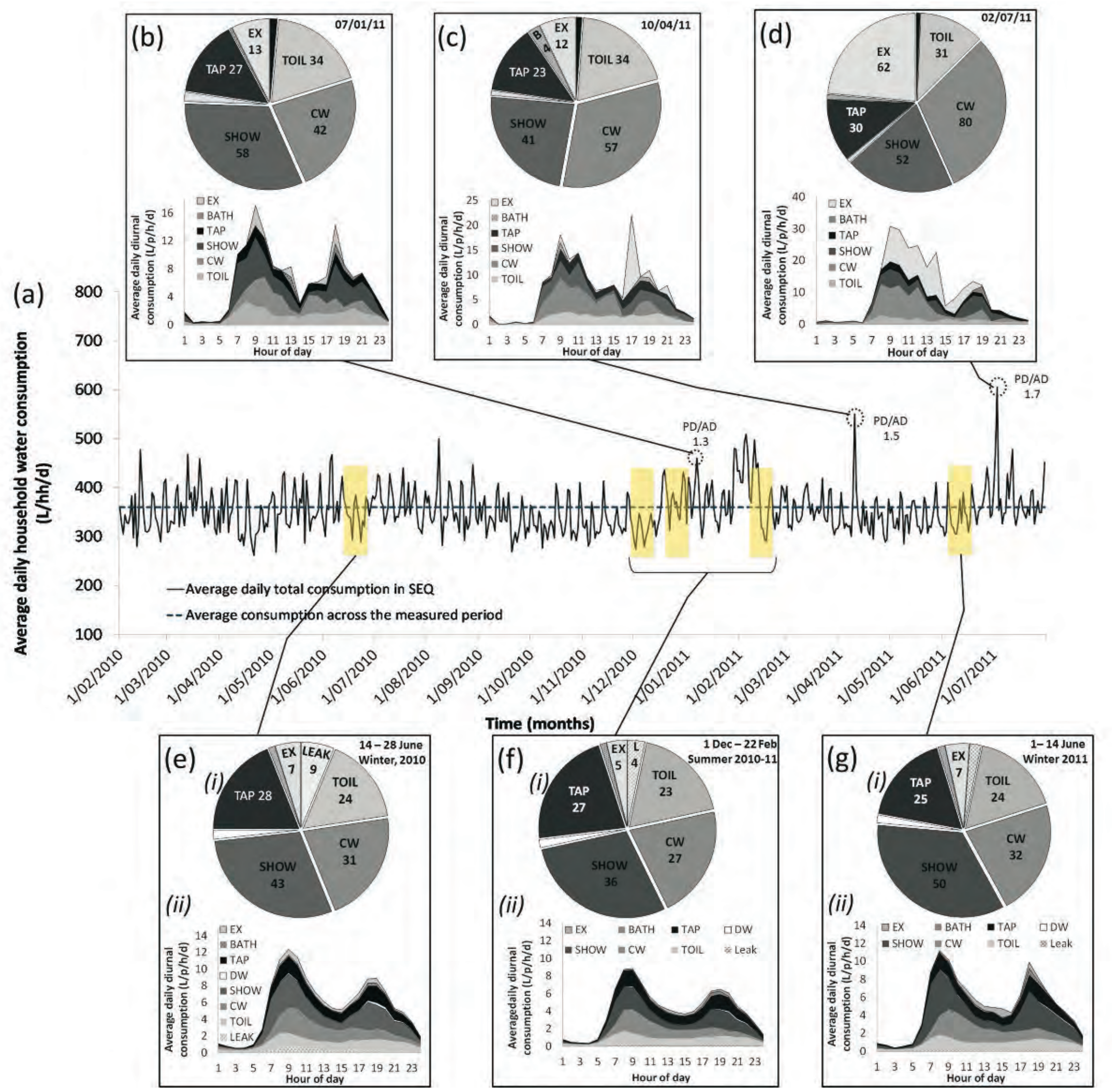
What Makes Water Metering Systems Intelligent?

The terms "intelligent" and "smart" metering are often indiscriminately associated with some combination of technology that is in some way superior to conventional metering. This inherent ambiguity is, however, indicative of the plethora of technological configurations intelligent metering covers, and its relevance to both the energy and water sectors. For example, automated meter reading systems (AMR) are often sold as intelligent metering systems, but they merely serve as a better way to collect customer water use data and rarely better inform utility operator or customer functions. Put simply, an intelligent metering system, should at a minimum, enable remote reading of water flow (consumption) and other optional data (e.g. water quality, pressure, etc.) at a resolution which improves current operational and customer decision making (e.g. collected in litre increments at least hourly), include accessible and user-friendly data registries of collected data, and autonomously produce readily accessible and useful reports for a range of purposes.

This latter requirement is really the core component of an intelligent metering system; big data alone without effective and efficient data mining methods and informatics algorithms to achieve enhanced decision making is really not that intelligent at all and will actually bog down water utility operations.

"Hydroinformatics is the key to unlock the benefits of the intelligent metering and big data revolution"

Figure 1: Example of how intelligent metering data can aid better understanding of daily diurnal demand patterns and peak demand (Beal and Stewart, 2013)



Drivers of Intelligent Water Metering

The diffusion of intelligent water metering into the urban setting has been slower than that of electricity. However, the cost for intelligent water meters has recently reduced to below USD100, thereby creating prospects for much wider deployment. Internationally, large scale deployments are rare (e.g. New York). Consequently, the drivers for intelligent water metering are not yet fully articulated, and nor is the cost-benefit proposition for intelligent water metering understood. To date, drivers for deployment include:

- Better understanding of time-of-day residential and commercial consumption to inform enhanced water supply design and management functions;
- More accurate accounting of water supply;
- Increasing water end-use or micro-component insights into consumption;
- Identifying and rapidly rectifying water losses in distribution networks and within customer connections (e.g. rapid toilet leak identification);
- Exploring the potential for alternative water pricing structures that are cost reflective;
- Seeking to enhance customer satisfaction with water utilities through providing enhanced information-based services (e.g. water bill budgets, leak alerts, etc.); and
- Seeking behaviour change in consumers through in-home displays, web-portals and smart phone applications.

Barriers to Intelligent Water Metering

To ensure that intelligent metering makes a positive contribution towards sustainable urban water management, a number of factors must be considered (Boyle et al. 2013). Handling big volumes of data generated by intelligent metering is a critical challenge, and could potentially revolutionise the way utilities operate. Further work to understand the implications of this change are needed. Additionally, more focus ought to be directed to customer needs. Given that the urban water sector is still largely within the government or quasi-government domain and enjoys monopoly status, the focus on customer satisfaction has been poor when compared with other privatised utility sectors such as telecommunications. Even the concept of harnessing basic information technologies such as the humble web site to convey simple water use and billing information is a foreign concept to many water utilities.

"Intelligent metering implementations are a process re-engineering exercise and not a technology adoption exercise"

However, implementing change with a poor understanding of customer needs has the potential for customer backlash, which has occurred in the more progressive electricity industry. Certain interest groups are strongly against intelligent metering, citing issues such as new pricing structures, security, health impacts from data transmissions, service interruptions and privacy. Giurco et al. (2010) discussed in detail the impact of collecting, collecting and communicating detailed water-use information on householder privacy. Issues with the management of data will arise if knowledge from intelligent systems is not properly and effectively managed by the utility. Thus, new skill sets for utility employees, including meta-data handling, information management and customer engagement is required when implementing intelligent systems. Utilities that choose not to acquire such skill sets, and outsource associated IT tasks, can incur the risk of technology vendors that propose off-the-shelf solutions that are ill-suited. The outsourcing option could also result in telecommunication companies or internet providers, already proficient in managing data and customer needs, to take on the management of water utility data. Therefore there is a very real need for utilities to adapt to the intelligent meter and 'big data' age, and lead the implementation effort based on theirs and their customers' needs. The future of the water utility will be data rich, hence water utilities need to adapt.

"Intelligent metering uptake is slow due to a limited focus on the back end data mining and analytics functionality as well as front end user orientation"

Still Unfulfilled Benefits of Intelligent Metering

The benefits of intelligent metering have been declared at many conferences by the growing hoard of companies seeking to be the global leader of this burgeoning industry. However, while 'product' is ready many of the potential benefits of intelligent metering systems have been unfulfilled due to the lack of focus on the necessary data mining and analytics functionality required for re-engineering the way the water utility sector goes about its business. Many of the unfulfilled benefits of intelligent metering include:

Better citywide urban water planning: intelligent metering enables better understanding of the water consumption patterns of a city's various residential, commercial and industrial customers and will aid urban water planners to better understand consumption trends and extract greater efficiencies from the present system.

Near real-time water distribution network analysis: Accurate and up-to-date demand data collected at a high resolution (Figure 1) is essential to ensure that future mains water supply networks reflects current usage patterns and are designed efficiently from an engineering, environmental and economic perspective (Beal and Stewart 2012).

Targeted water demand management: The prevalent reactionary policies to reduce water demand in supply crisis highlights the need for more detailed information at the "coalface". The use of intelligent metering and subsequent datasets could significantly improve decision making in relation to water demand management strategies.

Evidence-based water demand forecasting: Total and disaggregated water consumption data will also allow water businesses to monitor the effect of scarcity pricing or restriction regimes on water consumption in near real-time, and also monitor rebound trends following the removal of these strategies.

Proactive water loss management: A real-time monitoring system would also enable water utilities to intervene as soon as an exception alarm is raised (Britton et al. 2013).

Targeted demand efficiency: Regular monitoring of end-use consumption data provides the ability to immediately quantify the effect of targeted water efficiency programs on their intended water end-use(s) (e.g. can instantly establish savings from a washing machine rebate program implemented in a city).

Addressing water-related energy demand: data from intelligent water metering systems coupled with energy specifications for water supply products and fixtures (e.g. pumps, water heating systems, etc.) enables unpacking of water-energy nexus implications.

Evidence-based economic assessments: Intelligent metering and water end-use data provides opportunities for detailed financial analyses on the cost and water saving benefits of implemented water supply programs, ultimately driving a true least cost planning agenda.

Cost reflective urban water tariff reform: Intelligent meters can also inform the development of different tariff systems (e.g. scarcity pricing) to influence consumption behaviour. While there are many fears related to tariff reform, it potentially has strong advantages for reducing consumption in water scarcity periods, peak network periods, etc. thereby reducing the average cost of water supply for the entire customer base.

Heightened customer satisfaction: The present customer water information and billing arrangements are vastly inadequate. An intelligent metering system provides the impetus for a new approach to knowledge transfer of water consumption data, directly to consumers via a range of communication platforms and in-house displays.

Hydroinformatic Experts - A Call to Arms!

Concurrent with technology diffusion must be the reform of water utility operations management and its people. Much of this reform revolves around thinking about how the introduction of new and abundant data from intelligent meters can bring about efficiencies and improvements to the day-to-day tasks of employees.

Expertise in the design and implementation of intelligent metering systems, including the collection, storage, processing and useful reporting of information to operators and customers, is the key skillset to yield all the benefits of the forthcoming intelligent metering revolution. This task is complex since it requires a new breed of multi-disciplined water professional that understands all the planning, engineering and customer service functions of a water utility but also has a strong understanding of the computer science discipline, including database design, pattern recognition, computer programming, to name a few. The road has not been paved for this new area, so hydroinformatics researchers have a role to tackle these new problems and carve out a path for budding practitioners.

Specific areas of required research attention from urban hydroinformatics researchers, engineers and planners, in order to extract the full benefits of intelligent metering include, but are not limited to, the following:

- Algorithms and decision support tools that utilise the intelligent water meter fleet in the network and individual premises to identify the location and type of leaks that are occurring in real-time based on their flow pattern (e.g. toilet leak in residential premise identified and owner alerted automatically by SMS to phone).
- Algorithms which can autonomously disaggregate residential and non-residential water consumption into end-use/micro-component categories (e.g. Nguyen et al. 2013) and provide this information back to customers and utilities in a useful manner.
- Near real-time integration of flow meter data from distribution pipes with individual customer flow meters to allow real time network modelling of pipe networks and transition engineers towards just-in-time augmentation decision making.
- Databases and associated algorithms that can extract useful water consumption information to customers (e.g. enables customers to compare their consumption with others in their suburb) and water utility operators (e.g. can instantly reveal the water savings of a showerhead retrofit program in their city).
- Full integration of water consumption and billing information systems to enable customers to follow their progress towards set water budgets and utilities to explore potential alternative tariff structures.

References

Beal, C. and Stewart, R.A. (2013) Identifying residential water end uses underpinning peak day and hour demand. ASCE Journal of Water Resources Planning and Management, DOI: 10.1061/(ASCE)WR.1943-5452.0000357.

Boyle, T. Giurco, D. Mukheibir, P. Liu, A. Moy, C. White, S. and Stewart, R. (2013) Intelligent metering for urban water: A review. Water, 5, 1052-1081.

Britton, C., Stewart, R.A., and O'Halloran, K.R. (2013) Smart metering: enabler for rapid and effective post meter leakage identification and water loss management. Journal of Cleaner Production, 54, 166-176

Giurco, D. White, S. and Stewart, R.A. (2010) Smart metering and water end-use data: conservation benefits and privacy risks. Water, 2(3), 461-467.

Nguyen, K.A. Stewart, R.A. and Zhang, H. (2013) An autonomous and intelligent expert system for residential water end-use classification. Expert Systems with Applications, 41(2), 342-356.

Stewart, R.A. Willis, R.M. Giurco, D. Panuwatwanich, K. and Capati, B. (2010) Web-based knowledge management system: linking smart metering to the future of urban water planning. Australian Planner, 47(2), 66-74.

HYDROINFORMATICS IN THE SERVICE OF THE QUALITIES

BY ZORAN VOJINOVIC AND MICHAEL B. ABBOTT

Our knowledge and understanding of the nature and behaviour of water, and all that water maintains and destroys, has undergone a significant transmutation over the last few years (e.g. Vojinovic and Abbott, 2012). The subject of 'urban flooding' provides illustrative examples of how our ways of thinking have changed.

Some of the early efforts in dealing with floods and flood-related disasters were only concerned with the construction of structures (e.g., levees, floodwalls, dams, embankments, storage basins, diversions, etc.) without significant consideration of aspects which are nowadays regarded as equally important, if not more important. Inspired by the realisation that flood risk can hardly ever be completely eliminated; the traditional 'flood defence' culture has been replaced with the culture of learning how to live under flood risk and how to better respond to it. However, despite the fact that our thinking has changed significantly over time and even though our technological capabilities for dealing with floods have advanced rapidly, the records show that floods still have the fastest rate of increase in relation to other types of disasters: see Figure 1. Devastation due to these events occurs almost daily. This paradoxical situation proves that our earlier ways of thinking are inadequate and that we must undergo a major shift in this very way of thinking and its corresponding values and practices.

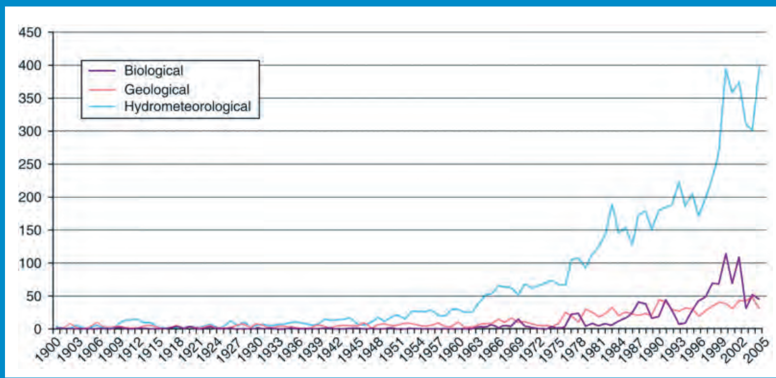


Figure 1: Trends of 'natural disasters' (Source: International Disaster Database EM-DAT, University of Louvain, Belgium)

From the Mechanistic to a Holistic Worldview

Despite our deep respect for modern science, most of the current research and practical efforts appear to be the same as those that have become so characteristic of modern science generally, namely those of ordering, numbering, counting and computing. Modern science has set humanity on a path to address many of its problems, where dealing with floods is just one example, by using its logics, its disciplines, its technologies and its observations, while ignoring the world of qualities as means for uncovering the reality of the phenomena. Such qualities as feelings, emotions, ethical sensibility, consciousness and spirit are absent from modern science and its scope has been restricted to the study of phenomena that can be measured and quantified. Furthermore, the modern scientific paradigm is based on the premise that in every complex system (or phenomenon) the behaviour of the whole can be understood entirely from the properties of its parts, which is a mechanistic or reductionist way of thinking. This kind of thinking has influenced our narrowly-focused academic disciplines which can only represent different parts of the 'reality' that we experience. Undoubtedly, this thinking has on the one hand provided great benefits, but on the other hand it has also brought many side-effects. Today, we can observe great technological discoveries on one side but on the other side we are witnessing our inabilities to deal with economic crises, inflation, poverty, energy shortage, pollution, natural disasters and so on – and on. The predominance of almost exclusively *techno-centric* and *piecemeal* approaches which put the *economic prosperity* and *growth* as first (or most dominant) values to be preserved, above social, cultural and ecological well-being, has led to the development of less sustainable and less efficient means of responding to any kind of crisis.

It is now becoming obvious that the present way of thinking has created a profound cultural imbalance in our way of looking at life and as such it lies at the very root of many of our crises including the crisis in our search for sustainable living, where dealing with floods is just one part. In view of the limitations of modern science, and consequently of the present-day ideologies, which have nowadays become so evident, we have to undergo a new paradigm shift in our thinking and our practice. We have to undergo a shift towards a holistic paradigm which can change our perception from a disciplinary and defensive one into a trans-disciplinary and progressive (and indeed transcendental) one that turns challenges into possibilities for a change that can re-shape our future.

The Rise of Holistic Thinking

As introduced in Vojinovic and Abbott (2012), the prevailing modern scientific way of thinking that dates from the *Condemnations in Paris of March, 1277* – has been an analytical (i.e., a mechanistic or reductionist) way of thinking. This way of thinking is still successful in many cases, but it does have the effect of shifting the focus away from the phenomenon itself, which then only takes the second place. As opposed to the analytical way of thinking there is a holistic way of thinking which is based on the premise that the properties of the parts are not intrinsic properties of the whole and that they can be understood only within the context of the larger whole. Such a way of thinking emerged through different disciplines and movements, and these are the subjects of phenomenology (e.g., Brentano, Meinong, Husserl, Heidegger, Max Scheler, Merleau-Ponty, Sartre and others), Gestalt psychology (e.g., Ehrenfels, Koffka, Wertheimer and Köhler), organismic biology (e.g., Harrison, Henderson, Woodger and others), romantic movement in art, literature and philosophy (e.g., Goethe, Blake, Kant), ecology (e.g., Haeckel, von Uexküll, Lovelock, Patten and others), general system theory (e.g., von Bertalanffy), cybernetics (e.g., Wiener, Forrester), quantum physics (e.g., Planck, Heisenberg, Bohm and others), Category Theory (e.g., Freyd and Scedrov) and so on. Henri Bortoft has so brilliantly summarised the words of some of these great thinkers (see Bortoft, 2013).

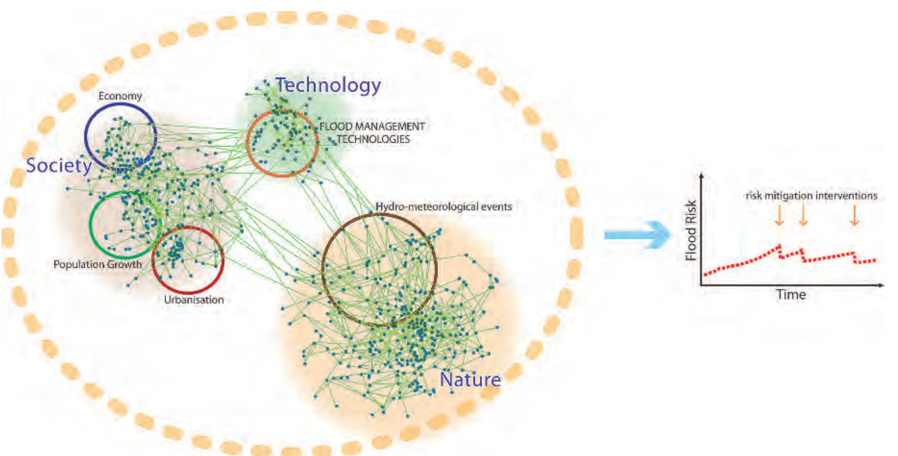
As mentioned above, holistic thinking has been expressed repeatedly, in one way or another. However, mathematical models of complexity and multiple relationships gained interest only recently with the advances in computational power which allowed us to model the nonlinear processes associated with interconnectedness and interactions. Consequently, several mathematical concepts and theories have emerged. Such examples are: category theory, complex adaptive systems theory (complexity theory), multi-agent system theory (agent-based models), evolving automata, game theory, nonlinear dynamics theory, chaos theory and fractal geometry, computational sociology, autopoietic network theory, and so on.

A holistic way of thinking and working draws from the understandings brought by *phenomenology* and *complexity theory,* where individual elements co-evolve together, both in development and application, Figure 2. To place this in the context of flooding, phenomenology shifts the focus from the traditional way of thinking about flooding as that which appears (which resembles the final result) into the thinking of flooding as the experience of the *appearing* of what appears (which is a holistic, or dynamic, way of thinking, i.e., thinking in terms of complexities, relations and interactions between the root causes that can lead to flooding as a collection of phenomena, in the exact Husserlian sense, Husserl, 1900, 1901/1913). This way of working aims for a more profound engagement of those affected (i.e., stakeholders) who are seeking multipurpose (or multifunctional) solutions which are not only technologically and economically efficient, but which are also ecologically sustainable and socially just (Vojinovic, 2014). This way of thinking and working is now the way forward for hydroinformatics.

From a Hydroinformatics of the Quantities to a Hydroinformatics of the Qualities

Hydroinformatics was born when numerical modelling and data collection and processing came into a synergic relation at the end of the 1980s (Abbott, 1991). By that time the field of numerical modelling had expanded its range from one that was restricted to the modelling of flows of water exclusively to a much wider-ranging field that combined flows and all that these flows transported with them, which increasingly included living creatures that had, in turn, their own means of locomotion (Abbott, 2002). With the extension of hydroinformatics onto the sociotechnical dimension, the role of hydroinformatics has turned into a *transmutation* of the corresponding social environment from a reactive one into an interactive one. Although we have been traditionally concerned for the most part with a *hydroinformatics of the quantities*, where the qualitative dimension has largely been overlooked, the focus now, and increasingly, has to be shifted towards a *hydroinformatics of the qualities*. It is then important to emphasise here that hydroinformatics is no longer only about numbers, even as it continues to be based to a large extent upon the use of numbers, but it is also about such qualities as perceptions, experi-

Figure 2: Formation and propagation of risk is the result from the coevolutionary nonlinear process between the ever changing social, technical and natural processes. Dots represent sub-processes and activities and lines represent their interactions (Source: Vojinovic 2014)



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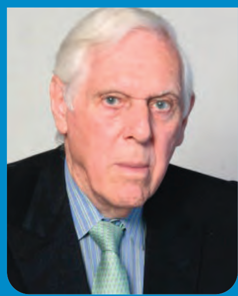

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Figure 3: Flooding in the Historic City of Ayutthaya, Thailand (November 2011 - Photo: Z. Vojinovic). The Ayutthaya heritage monuments have an immense intrinsic cultural significance which cannot possibly be expressed in monetary terms

ences and emotions, including some of the deepest emotions of mankind and, if only through surrogation, of so many other creatures in the world of nature besides. Thus, even as we may want to compute the movements of populations under flood conditions using traditional methods of modelling, we now move into the world of qualities when describing states of being in these populations.

This brings the importance of *hydroinformatics environments* which use dynamic, highly-detailed and relevant illustrations, almost always in colour, of the objects that are of the greatest concern to the individual participants and to the society as a whole, who are then represented by their active stakeholders (Vojinovic and Abbott, 2012). The value of the psychic means of personalised perception as opposed to the modern-scientific means of impersonal perception lies in this direction, whereby the perception of a colour enhances the impact of an emotionally charged 'surreal' object and is no longer associated with an emotionally neutral 'real' object. Thus, when the user interface projects the streets along which the various families' children are walking to school, the blobs that represent the children may be simply 'children-coloured' when there is no danger from flooding, with the families correspondingly indifferent to any flood-related danger, but may appear flashing with an intensified 'children-colour' when these children are in danger and the parents may need to intercede. We may call this "thinking in terms of situations" and in this example it is realised by bringing the danger into coincidence with the potential victims in the minds of their parents, thereby contextualising their deepest concerns, whether to assuage them or to support them. We have to do here with an emotional impact which is entirely qualitative, even as it depends upon the quantitative resources of technology.

The above discussion implies that the traditional risk quantification process, which has been dominating the 'flood management practice' for some time must now be combined with qualitative considerations. The current decision-making practice has advanced in many areas but it is still dominated by the traditional cost-benefit type of analysis (i.e., CBA analysis). As discussed at some length in Vojinovic and Abbott (2012), this approach may appear appealing but it is very much a simplistic way of assessing the benefits of different measures (including flood protection standards and potential damages) even as *the qualities*, such as ethical, cultural, historical and ecological values are almost completely left unattended.

As the holistic way of working aims for a more profound engagement of stakeholders who are seeking for multipurpose (or multifunctional) solutions, our search for such solutions also brings the opportunity to question our current values which are often at the root cause of deeper social inequalities and our unsustainable relationships within the society and with the nature. Hence, the search for multipurpose solutions can be seen as a purpose of a larger whole that consists of a variety of purposeful (i.e., teleological) sectoral activities (i.e., activities of 'smaller' wholes) that all contribute towards the larger purpose (Vojinovic 2014).

To illustrate the holistic way of searching for multipurpose (or multifunctional) solutions we can consider for a moment problems associated with climate extremes that are nowadays causing extreme rainfall and flooding on one side and drought and heat waves on the other. In response to threats from droughts, some cities in the coastal zone have embarked on building desalination plants as a measure to mitigate shortage of drinking water. Looking from a wider perspective, this measure is only shifting our dependency from rainfall (which is needed to fill in our reservoirs and dams) to dependency on energy (which is needed to operate such plants) and does not seem to be sustainable on the long run. At the same time, we are not sufficiently harvesting our other sources of water which can be used to preserve our drinking water reserves. Storing rainwater on sites which have multifunctional purposes can bring greater efficiency of land use. Also, since the availability of space is scarce in urban areas, we can also consider how to utilise the actual water surface in a multifunctional way. A good example of multifunctional use of the water surface is the construction of floating buildings. Furthermore, to deal with the challenge of energy scarcity and to minimise the ecological footprint it is important to develop solutions that can utilise internal sources of water, energy and nutrients first before we go on extracting resources from other areas. Urban wastewater contains high amounts of phosphate and nitrates which could be used as fertiliser for urban agriculture and development of productive landscapes. It can be also used as a source of heat and for biogas production. Productive landscapes can have multiple functions as they can serve not only for amenity and recreational purposes but also to keep our urban sites fresh and cool during heat waves as well as for urban farming. This can be then placed into the context of water - energy - food security. Furthermore, the same holistic thinking would also aim to seek for those multi-purpose solutions that can also promote job creation and reduction in antisocial behaviour and *injustice* (Vojinovic 2014).

Overall, the way forward can be found only if we broaden our view and learn how the natural or social phenomena can provoke a response in a society, or a social group, which in turn can trigger the technical developments, and so on, again and again, in what becomes a network of interactions and relationships through positive feedback (or coevolving) cycles. This recognition opens a new way of analysis which goes beyond the direct objects or actors of concern (development of policies, development of technology for flood mitigation and design of adaptive systems for example), and into the relationships between them. Hence, our planning for more effective resilience requires not only sound engineering knowledge but also a much deeper understanding of *the qualities*, which in turn necessitates a new way of thinking and working within *hydroinformatics*.

References

Abbott, M. B., (1991). Hydroinformatics: Information Technology and the Aquatic Environment, Avebury Technical, Aldershot, UK. and Gower Publishing, Brookfield, USA.

Abbott M.B. (2002). On definitions. J. Hydroinf. 4 (2), electronic version only. Also available at: http://www.knowledge-engineering.org

Bortoft, H., (2013), Taking Appearance Seriously: The Dynamic Way of Seeing in Goethe and European Thought, Lindisfarne Books and Floris Books, Edinburgh.

Husserl E. (1900, 1901/1913). Logische Untersuchungen. Niemeyer, Halle // 1970 Logical Investigations (transl. Findlay, J.N.). Routledge, London.

Vojinovic, Z., and Abbott, M. B., (2012), Flood Risk and Social Justice, IWA Publishing, London.

Vojinovic, Z., (2014), Flood Risk: The Holistic Perspective, From Integrated to Interactive Planning for Flood Resilience, IWA Publishing, London.

INTEGRATED ENVIRONMENTAL WITH OPENMI AND FLUIDEARTH

BY QUILLON HARPHAM AND PAUL CLEVERLEY

Integrated Environmental Modelling
It is becoming increasingly recognised that many modern environmental questions cannot be answered by simulating physical, chemical or biological phenomenon in isolation.
Environmental systems typically involve a variety of natural processes working together. The environment is an interconnected system and multiple, dependent environmental phenomenon may interact resulting in consequences which were not expected if each had been considered independently. If we wish to use numerical models to simulate these processes accurately then our modelling methods must take into account their interactions as well as accurately simulating each individually. The phenomena must be allowed to influence one another's behaviour. For example, a flood may be a combination of groundwater and surface water. At some places, the groundwater feeds the surface water; at others the surface water feeds the groundwater. We need to understand both together to correctly predict the outcome. This being the case, the only way to successfully answer these questions is to employ integrated approaches which allow this to happen. These will often span disciplines, to complement the traditional single discipline methods.
A number of approaches exist for achieving this. One is to embody the interactions of all relevant phenomena in a single 'super-model', that is, create a single numerical modelling application which incorporates all necessary processes. However, this can quickly produce an application which becomes unwieldy, difficult to develop and support and ultimately vulnerable by its dependence on certain key individuals. Indeed, it is becoming clear that one single numerical model cannot be sufficient to represent all of the details needed for decision making and planning.
Another approach is to simulate complex systems by integrating multiple, smaller models that collectively simulate the larger problem in question, that is, to build an integrated composition of previously independent numerical models and run them together. In its simplest form this can be achieved by taking the output of one model and using it as the input to another. Such a 'one-way' interaction has been common in environmental modelling for many years. Requirements have since developed to demand a more flexible, interoperable and extensible solution. Moreover, a 'two-way' connection between numerical models is often required. Both models need to be given the opportunity to influence each other. It is desirable for each component to remain sufficiently independent so that experts can remain in their disciplines, yet are able to communicate model outputs clearly where necessary at the interfaces between their coupled models. Indeed, achieving this in a standardised fashion will better enable easy extensibility of the integrated composition to incorporate new parameters and to exchange similar numerical engines where appropriate.

The OpenMI Standard
OpenMI is a software component interface standard for the computational core of a numerical model. It was developed by leading hydraulic centres across Europe as part of projects part funded by the European Commission as a response to EU Water Framework Directive calls for integrated water management. As such, it was originally developed as a means for coupling existing models which would typically consider the interactions of environmental processes, in particular involving water. The computational core (or engine) of a numerical model is designed or adapted to be 'OpenMI Compliant'. Such compliant components can then be put together in OpenMI integrated compositions. This would typically occur between two components running simultaneously through time-steps which span a time horizon. They would then send and/or receive data at specific time-steps as each proceeds through its respective time interval. In this way, the two model components can both influence the results produced by the other at each point where data is exchanged. The linked components may run asynchronously with respect to these time-steps or proceed through together. OpenMI also supports one-way passing of data from a driving component to a second, set up only to receive. The latest version of OpenMI, version 2.0, was released in December 2010 at a specially convened reception during an EU-US summit in Washington DC. A short history of OpenMI is available on the OpenMI Association website (1).

The FluidEarth Implementation of OpenMI
OpenMI can be represented on paper as a set of object interface specifications. In order to save software developers having to create these interfaces from the paper definitions, the OpenMI Association publishes a set of open source reference interfaces in C# and Java on Source Forge (2) and encourages developers to use these.
In addition to the standard itself, the OpenMI Association pledges to accompany each release of OpenMI with two tools:

- A Software Development Kit (SDK) allowing numerical model developers to more easily make their model engines OpenMI compliant;
- A Graphical User Interface (GUI) allowing numerical model users to build and run compositions of OpenMI compliant components.

HR Wallingford's FluidEarth 2 is an implementation of OpenMI 2.0 for Windows .Net 4.0 consisting of a set of such tools which provide an environment for the standard to be used. FluidEarth began as an implementation of OpenMI 1.4 and has been upgraded to FluidEarth 2 to meet the specification of this new OpenMI standard. The SDK is called the 'FluidEarth 2 SDK' and the GUI, 'Pipistrelle' (a follow up to the OpenMI 1.4 version of Pipistrelle and the OpenMI 1.4 Configuration Editor). They are Open Source and available on SourceForge (3). They are the only such open source tools available so in this sense they act as the reference SDK and GUI for OpenMI 2.0 with Windows .Net. The FluidEarth 2 project has also provided a comprehensive training website and examples, both ready for use and to act as templates for the user's own components (4).

MODELLING

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FluidEarth community interaction takes place on the FluidEarth portal (5). All are welcome to join the community and contribute.

Test Cases

We now introduce some of the concepts involved in integrated modelling by looking at a set of test cases. The models have been derived to explore and illustrate different aspects without being too complicated in themselves.

The first test case is the 'Simple Pond'. It is taken from the FluidEarth training website (4) and is one of the simplest examples of an OpenMI component. The objective of this example is to allow the user to grasp some of the basic concepts of using OpenMI 2.0 with FluidEarth 2. The Simple Pond component has three arguments: capacity, current-level and flow. Water drains out of the pond as the composition proceeds through time-steps. The first composition given in the training, with the Simple Pond model given in C# and FORTRAN, shows the pond as the only component in a stand-alone composition.

A simple corollary proceeds with a composition of one Simple Pond draining into its twin. This second composition draws the user into a concept common to model coupling technologies – that of having to adapt the outputs of one numerical model before it can be connected to a second model. Since components in typical OpenMI compositions will have been developed independently and will have been designed to meet different requirements it is highly unlikely that it will be possible to simply connect the components together. Some sort of adaptation will be required in order to pass data between them. This can occur for a variety of reasons ranging from differing spatial structures to differing definitions of environmental phenomenon. In the Simple Pond example, the most straightforward of these is represented – that of a unit conversion. Pond #1 drains in centilitres, yet Pond #2 is expecting millilitres. Figure 1 illustrates this composition. OpenMI version 2.0 allows for this adaptor concept with the adaptors independent of the components.

The second test case, again taken from the FluidEarth training website, is the 'Two-dimensional Pond'. The theme is continued but a geospatial structure is added to the components. Each pond in this example offers an output array at each boundary, evenly spread across each length to represent water transfer across the entire length of each pond edge. When two such pond components are joined in a composition the action is similar – fluid will flow from one part of the pond to another as it drains into a second, identical pond component along a boundary. The nodes of the eastern boundary of the first pond match to the nodes on the western boundary of the second pond one-to-one, with values passed directly between the two.

Removing the assumption that the arrays along each boundary edge are the same size brings in the need for an adaptor. In figure 2, the 'ten-node' eastern boundary of Pond #1 needs to be connected to the 'five-node' western boundary of Pond #2. Without a one-to-one mapping of outputs to inputs an interpolation adaptor allows values to be successfully passed between these two pond components.

The third FluidEarth 2 test case represents an example more typical of 'real world' usage of the FluidEarth 2 toolset. The OTT2D model is a two-dimensional shallow water solver employing a collocated finite volume scheme. It is used in conjunction with a sediment continuity equation

Figure 1: The simple pond composition

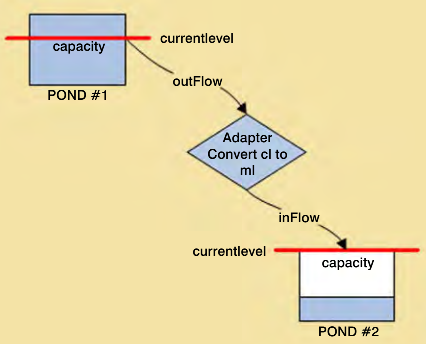

Figure 2: Connecting two-dimensional ponds of different boundary dimensions

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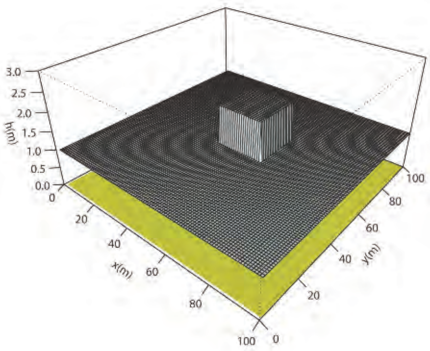


Figure 3: Bed deformation test case initial conditions

solver called Exner which considers sediment movement to calculate changes in river and sea beds caused by the movement of the water. A notional cube of water is held above water at a constant depth, to create a wet-wet dam-break type scenario (see figure 3).

The dam (cube) walls are then assumed to vanish instantaneously creating a shock wave, or bore, that propagates outwards towards the domain boundaries. This causes a deformation of the bed. The meshes for the two solvers are not coincident and so the OTT2D FluidEarth 2 OpenMI component is connected to the Exner FluidEarth 2 OpenMI component via an adaptor, a bivariate interpolator. Figure 4 shows the total bed evolution after four seconds of the simulation.

For the final test case we consider a composition involving a two-way connection between components. In such two-way compositions, components pass data to each other on demand as the composition runs, with each model advancing its internal time. Component A requests data from Component B which runs through sufficient internal time-steps until it can fulfil Component A's request. Similarly Component B may reach a point where it needs to request data from Component A. Component A then runs through sufficient time-steps until it, in turn, can fulfil Component B's request. One component will be the prime driver of this composition (connected to the run trigger) and its completion will signal the completion of the composition itself.
Such a bi-directional exchange of data between components may result in deadlock: Component A is waiting for Component B to fulfil its request for data, but Component B cannot do so until it receives data from Component A. Neither component can proceed and the composition fails to complete successfully. Pipistrelle provides a solution to prevent such deadlock situations occurring: if a

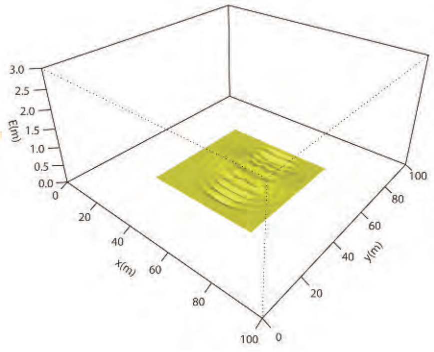


Figure 4: Total bed evolution at t=4s

component is asked for information that it cannot provide by computation (for example because it would be relying on data supplied from the requesting component) then the component is forced to provide a value, even if it has to approximate.
We explore this concept with FluidEarth 2 through a composition connecting two reservoirs, A and B, by two independent channels. One channel allows water to be pumped from A to B only, the other from B to A only. The starting level of reservoir A is higher than that of B and the system is set up to attempt to reach equilibrium. Figure 5 shows a screenshot of the composition in the Pipistrelle GUI.

When the composition is run we find that water is pumped from A to B until the levels are approximately equal, yet at the point where equilibrium is expected, the system oscillates

Figure 5: Two-way reservoir coupling in Pipistrelle

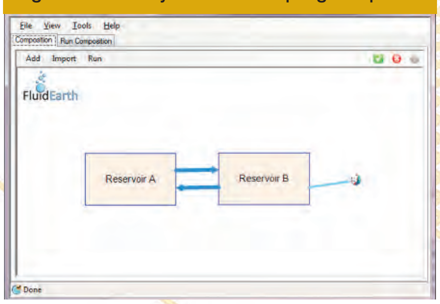
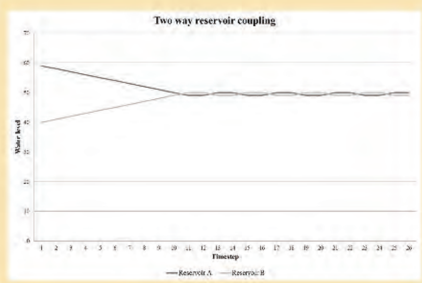


Figure 6: Two-way reservoir coupling composition results



indefinitely with water levels crossing over. Figure 6 shows these results in a chart of water level against model time steps. This is an example of numerical model instability which can occur in such circumstances, often observed at transition points where water flow changes direction.

Summary and Acknowledgements

FluidEarth 2 is an implementation of OpenMI version 2.0 which seeks openness, flexibility and usability. The examples using the FluidEarth 2 SDK and Pipistrelle given above, range from simple one-way compositions to those more typical of real industry or academic requirements. They have been built in C# and FORTRAN (with Visual Basic usage seen as a corollary) where the model coupling process has been improved and made accessible to less technical users. Using the Pipistrelle GUI, compositions can be built utilising compatible components from different suppliers in a high usability environment. The training website includes a detailed level of instruction, especially for use of the SDK since this is the most involved procedure, tending to be the most esoteric.
This article has been summarised from a paper: Harpham, Q.K., Cleverley, P., Kelly, D. (2013) 'The FluidEarth 2 Implementation of OpenMI 2.0', currently under submission to the Journal of Hydroinformatics.
The FluidEarth 2 toolkit (Pipistrelle and the FluidEarth SDK) are open source developments freely available on SourceForge (3). The code was developed for HR Wallingford by Adrian Harper of Innovyze.
FluidEarth 2 was co-funded by the EC 7th Framework Programme DRIHM Project, Grant Number 283568.
OpenMI is governed by the OpenMI Association and OpenMI 2.0 is currently in the final stages of becoming a standard ratified by the Open Geospatial Consortium (OGC).

References

OpenMI Association (2012), Short History, OpenMI Association Website, http://www.openmi.org/new-to-openmi#TOC-Short-history. Accessed 21st August 2012.
OpenMI Association (2010), OpenMI SourceForge Project, http://sourceforge.net/projects/openmi/. Accessed 18th October 2013.
HR Wallingford (2012), FluidEarth SourceForge Project Open Source Development for FluidEarth, http://sourceforge.net/projects/fluidearth/. Accessed 18th October 2013.
HR Wallingford (2012), FluidEarth eLearning Website, http://eLearning.fluidearth.net, Accessed 25th October 2013.
HR Wallingford (2008), FluidEarth Portal, http://fluidearth.net, Accessed 25th October 2013.

Figure 1 – Embedding research into leading technology

21ST CENTURY ASSET MANAGEMENT

BY BEN WARD

The benefit of employing advanced asset management techniques has been widely acknowledged in the oil, nuclear and gas industries. Where-as the application of these techniques has been somewhat lacking for the management of long-lived water industry assets such as tunnels, conduits, masonry aqueducts and service reservoirs - until now.

Ben Ward **is a chartered civil engineer currently engaged in the research and development of Advanced Infrastructure Asset Management Techniques for the Water Industry. His research is being conducted on behalf of his industrials sponsors AECOM at the University of Exeter.**
Ben would like to acknowledge the continued support from EPSRC through their funding of the STREAM Industrial Doctorate Centre.

Leading research conducted at the University of Exeter by AECOM has integrated advanced asset management techniques within a specifically developed data capture and lifecycle management software application, provided by KyKloud. The software operates on a universal tablet device, iPad, and web-based cloud storage system that acts as the data depository and intelligent management system. The integrated approach offers an end-to-end asset management service that not only allows for efficient data collection and management, but provides a mechanism for asset managers to quantifiably prioritise maintenance and investment programs.

Background

Traditional approaches to estimating failure probabilities in below-ground water networks rely on historical failure data. Generally, where historical data is plentiful, statistical methods are used in which failure data is fitted to time-exponential functions, allowing for future failure rates to be extrapolated. Assuming good quality data, this does not pose a problem for low consequence assets, eg, small diameter mains or sewers, which are often operated under a "run to failure" strategy. However, for larger diameter, business-critical pipelines, service reservoirs or treatment processes, there is much less recorded failure data and proactive condition inspections are often required to pre-empt high consequence failure events.

Pre-emptive techniques for critical assets often take the form of visual condition inspections to ascertain the current operational and structural condition of the asset, as well as allowing for estimates to be made regarding the assets remaining service life and value. Whilst traditional condition inspection techniques are useful to help prioritise maintenance regimes, it remains difficult to benchmark the current performance of one asset against another, or, to evaluate how far along the deterioration process the structure may be. This is a common problem when the condition or performance of an asset is simply measured using a 1 (good) to 5 (poor) grading system.

Table 1. CSS Severity & Extent Tables

Severity Code	Description	Extent Code	Description	Weight	Description
1	As new condition or defect has no significant effect	A	No significant defect	0.0	No influence on the functionality
2	Early signs of deterioration, minor defect/damage, no reduction in functionality	B	Slight, not more than 5%	0.25	Severe deterioration would affect functionality
3	Moderate defect/damage, some loss of functionality	C	Moderate, 5% - 20%	0.5	Component is important to functionality
4	Severe defect/damage, significant loss of functionality	D	Wide, 20% - 50%	0.75	Component is critical to functionality
5	The element is non-functional/failed	E	Extensive, more than 50%	1.0	Component is critical to the overall structures functionality

An Alternative methodology

In recognition of the current limitations of basic structural condition grading systems, research has been conducted into an alternative methodology that can be used to translate condition observations into a more meaningful metric. The metric deemed most suitable to represent structural performance, is reliability; which can be denoted in equation 1 as:

$$\text{Reliability} = 1 - \text{Probability of Failure} \quad (1)$$

The advantage of being able to express condition in-terms of structural reliability is that it can be used to develop an understanding of risk (*probability of failure * consequence*) – thereby aligning with the UK regulators requirement to justify capital investment in this way (UKWIR, 2002). Reliability is expressed as a probable value on the y-axis of Figure 2, between 0 (highly unreliable) and 1 (highly reliable), depending on the component's ability to perform its required function. A Weighted Severity and Extent score is produced from structural condition observations which capture details of the "severity" of damage, its spatial "extent" and the "weighting" of each element which is used to express the criticality of each element in relation to the structures overall stability. The severity and extent principles largely follow the best practice established by the County Surveyors Society (CSS 2002) for bridge inspectors; where-by each component is assessed and scored under these measures in Table 1.

Both severity and extent are parameters that are used to inform decisions about maintenance planning and management. The use of separate codes for each parameter eliminates any obscurity in the distinction between, for example, a single but severe defect and extensive but superficial deterioration. Whilst the severity and extent scoring system is a mechanism to provide a consistent and quantitative indication of the visible condition of each sub-component making up the overall structure, it is not an indication of how the asset is performing. Therefore, a weighting factor was introduced into the approach to identify the differing degrees of criticality, or influence, for each of the structures sub-components on its overall performance. The mathematical translation from the severity, extent and weighting factor observations to a reliability value uses a logistic function to automatically position the Weighted Condition Score as a reliability value somewhere along the components reliability curve (dotted white line), Figure 2. Each component can be assigned a unique reliability curve using the logistic function, within the iPAD application, to account for the different deterioration rates for each component.

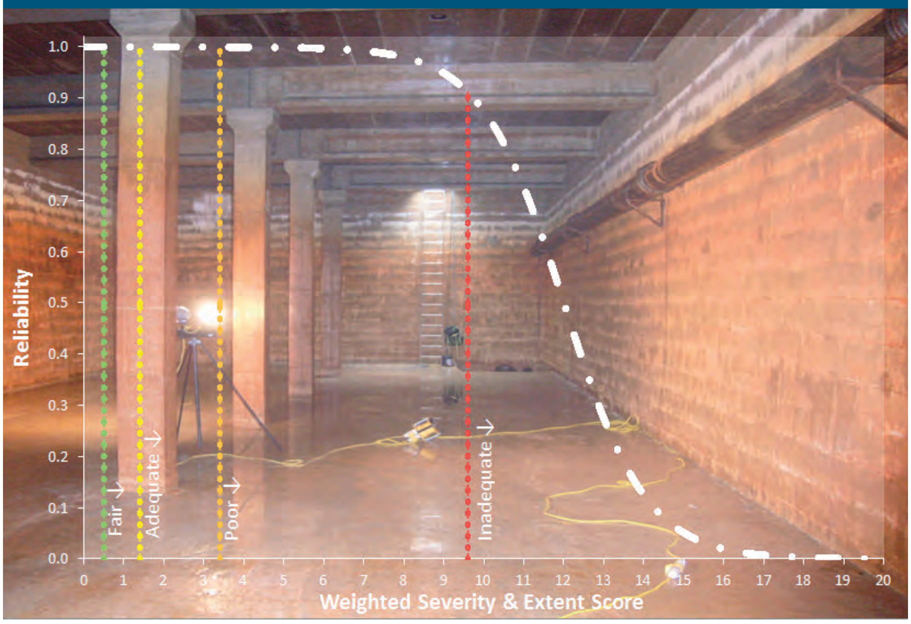
Modelling other Failure Modes

The previously described severity and extent scoring system is a mechanism that provides a consistent and quantitative indication of the visible condition of each sub-component that makes up the overall structure. On its own, the 'Severity and extent' information being captured is not sufficient to understand the overall performance of the asset. As such, an accompanying set of weighting tables have been created within the pro-forma to identify those elements that are critical to the assets functionality. Where-by the term "functionality" is used to describe the assets performance in respect to critical failure modes or performance measures. Using a service reservoir as an example, the failure modes considered here are structural stability; water quality; and health and safety. Therefore, the condition score for a particular sub-component is linked to the appropriate failure modes using weighting factors which act as a multiplication factor for all sub-components. The value of the weighting factor is pre-selected using engineering and operational knowledge, based on the importance of each sub-component on the overall functionality of the structure with respect to the failure mode(s) being considered. This in-turn produces a weighted condition score to assist with the prioritisation of defects according to the asset manager's priorities, i.e., structural stability, health & safety performance and/or water quality.

In Field Technology

It is widely recognised that on-site data capture and the management of condition inspection information is costly and time consuming. Coupled with today's emphasis on cost control and data quality, the need to deploy cost effective solutions for the purposes of accurate data capture is even more prevalent. In the transport industry, smarter data collection

Figure 2: Masonry Wall Reliability Curve



systems are more widely cited and similar solutions have been developed for building and property management. KyKloud is one such company offering secure cloud based platforms helping asset managers and operational teams to collect data efficiently and use this information to manage the life-time cost of major infra-structure/property portfolios (Wilkinson, 2012).

The KyKloud system has been integrated with this research to do exactly that. This model is based on a Capture-Manage-Report workflow, in line with the latest asset management industry standards ISO 55000, which sets out a process to host the new reliability modeling technology. The iPAD® inspection application is an innovative approach to field based data capture because it offers a number of unique features such as integrated condition grading, photo and GPS location tagging, that fit seamlessly within the online data management cloud to equip utility managers with an easy to use interface that provides instant access to their data for calculation and reporting.

Conclusion

The representation of condition inspection information as a justifiable reliability score held against each component of the asset, in a web-based geospatial environment, is the first step towards the deployment of advanced asset management programmes for long-lived water industry assets. It is widely recognised that the fundamental approach to risk analysis is the ability to define structural reliability and the associated consequence of the assets failure. This is supported in the UK Water industry through the introduction of the Capital Maintenance Planning Framework (UKWIR, 2002). The framework sets the industry benchmark for risk based decision making which has become a requirement imposed by the UK Water industry regulatory Ofwat to encourage water companies to consider the probability and consequence of failure when justifying capital investment.

However, it has been recognised that despite the successful application of the CMPF principals for assets with a robust history of failure, the principles present a number of challenges for assets with limited failure data; termed "long-life, low probability" assets (UKWIR, 2011). If risk can be expressed in a clear and quantitative manner, the job of decision making can be informed through an understanding of the true costs and benefits that are associated with the decision.

The methodology set out above demonstrates an enhanced approach for understanding and benchmarking the performance of water industry assets. The approach is founded on a severity and extent scoring system which is used to translate sub-component condition observations into reliability scores against a variety of failure modes, namely; structural integrity, water quality and health & safety performance. The authors have integrated this new methodology within an innovative iPad and Cloud storage data management system to provide an efficient and common framework complaint approach which is able to quantifiably prioritise maintenance and investment programmes of work.

The integrated approach has been applied to a series of service reservoirs and water hydrant inspections in the UK. For these programmes of work, significant benefits are being observed when compared to conventional condition assessment techniques. In essence, the approach offers an end-to-end asset management service for water utility providers which can be tailored to suit virtually all types of assets.

References

CSS Bridges Group (2002) Bridge Inspection Reporting: Guidance Note on Evaluation of Bridge Condition Indicators. , Volume 2.
UKWIR (2002) Capital Maintenance Planning: A Common Framework (02/RG/05/3)
Wilkinson, P. (2012) Kykloud targets asset management with SaaS and apps. Extranet Evolution. [online] http://extranetevolution.com/2012/01/kykloud-targets-asset-management-with-saas-and-apps/ (Accessed December 29, 2012).

IAHR COUNCIL

CO-OPTED COUNCIL MEMBERS

IAHR would like to welcome the new co-opted Council Members for the term 2013-2015

Peter Goodwin Peter Goodwin
Lead Scientist, Delta Stewardship Council
DeVlieg Presidential Professor, Director
Center for Ecohydraulics Research
University of Idaho
UNITED STATES OF AMERICA

Peter Goodwin is the DeVlieg Professor of Ecohydraulics at the University of Idaho, USA and is the Director of the National Science Foundation EPSCoR Program in Idaho. Currently he also serves as the Lead Scientist for the Delta Stewardship Council that is working to balance the co-equal goals of increased water supply reliability and ecosystem sustainability for California.
He was a Vice-President of IAHR from 2007-11.

Damien Violeau
Senior Scientist
Electricité De France, Division R&D
Laboratoire National D'Hydraulique Et Evironnement (LNHE)
FRANCE

Graduated from the french engineering college 'Ecole des Ponts ParisTech', Damien Violeau is senior scientist at the National Hydraulics and Environment Laboratory (LNHE) of the R&D branch of EDF. With 16 years of experience in coastal engineering and CFD, he has been involved in development and international co-operation on SPH (Smoothed Particle Hydrodynamics). He joined IAHR in 2003 as a member of the Hydroinformatics Section, then of the Committee on Coastal and Maritime Hydraulics, where he acted as secretary from 2006 to 2007. I direct the Hydro-environmental Research Centre, at Cardiff University, which currently comprises over 40 research staff and students. I Chair the UK Research Excellence Framework 2014 Civil Engineering Sub-Panel and am currently involved in a wide range of research projects as given on my website.

Robert Ettema
Professor of Civil Engineering and Dean
University of Wyoming
College of Engineering & Applied Science
UNITED STATES OF AMERICA

Ettema attained the PhD degree at Auckland University, New Zealand. His expertise encompasses several aspects of hydraulic engineering including cold-regions engineering. Besides research and teaching activities at the Universities of Iowa and Wyoming, he has been engineering dean at Wyoming, extensively consults for agencies and industry, and has served as Editor of ASCE's Journal of Hydraulic Engineering. He also has received ASCE's Hunter Rouse and Karl Emil Hilgard Awards.

2017 IAHR WORLD CONGRESS WILL BE HELD IN KUALA LUMPUR

INNOVATIVE FLOOD MANAGEMENT SYSTEMS

KUALA LUMPUR'S STORMWATER MANAGEMENT AND ROAD TUNNEL

BY NOR HISHAM GHAZALI

***Nor Hisham Ghazali,* Director**
SMART Stormwater Control Centre
Dept of Irrigation and Drainage
Malaysia

Malaysia's capital city Kuala Lumpur currently has a unique solution to tackle floods that have for many years plagued the city. The Stormwater Management and Road Tunnel (SMART) is an innovative project by the Government of Malaysia that not only alleviates the flood woes in Kuala Lumpur city center but also reduces traffic congestion. An integral part of the Kuala Lumpur Flood Mitigation Plan, SMART's primary function is to divert flood flows in the Klang River before it enters the city centre. Measuring a total of 9.7 km in length, 3 km of the tunnel serves as a motorway to ease the long-standing traffic congestion at the city's southern gateway at Sungai Besi. SMART is the first tunnel to incorporate a twin deck motorway component thereby making it the first dual function tunnel in the world. During fair weather when there is no need for flood diversion, the tunnel is used by traffic. The SMART concept is a departure from more traditional solutions whose implementation would have been constrained by the extremely high land and property values, limited river reserves and urban congestion, SMART offered an intrepid engineering solution to manage both the city's flood and traffic problem.

www.malaysian-explorer.com

SMART's Components

Two major rivers – the Gombak and the Klang – meet in the city center at the iconic Masjid Jamek (Figure 1). Historically, this confluence has been the flashpoint of most major floods in Kuala Lumpur. SMART is designed to protect Kuala Lumpur city center from a Q100 peak flow. The SMART system is a divert-store-release system with a diversion weir and offtake structure located upstream of the Klang River. During major storms in the upper catchment, the potential stormwater is first diverted into the Berembang holding pond before entering the tunnel. The water then flows 9.7 km by gravity to an attenuation pond at Taman Desa before being finally released into the Kerayong River, a lower tributary of the Klang River downstream of the city. The total storage capacity of the whole system is 3 million cubic meters.

The 3 km motorway section of the tunnel is located approximately in its middle third between the sub-districts of Kampong Pandan and Sungai Besi. Junction boxes at these points connect the traffic ingress and egress to the tunnel. For safety reasons, the double-deck design caters for one-directional flow of traffic in the tunnel. The lower deck is designed for city bound traffic and the upper deck for traffic leaving the city.

pre-cast concrete rings with inner diameter 11.8 m and a thickness of 500 mm. Each ring consists of 8 segments and a keystone.

Flood Detection System (FDS)

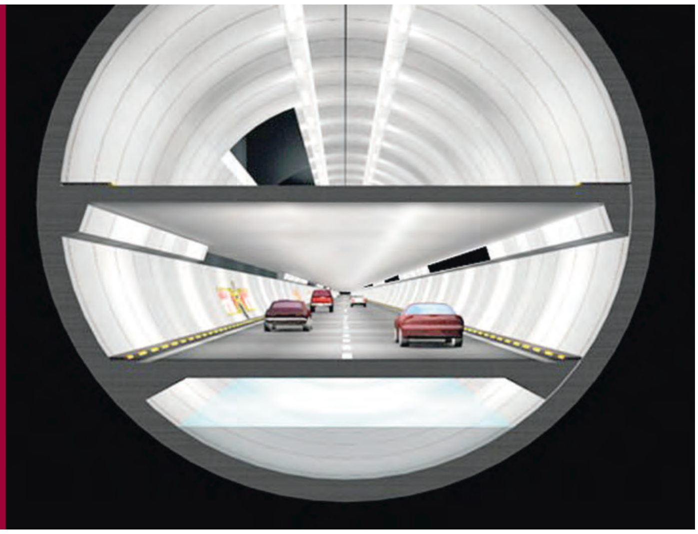
SMART's dual purpose requires an advance flood detection system to allow lead-time for tunnel mode management. This is in the form of the Flood Detection System (FDS) - a sophisticated SCADA and hydrological/hydraulic modeling system that provides real-time flood forecasting information to SMART's stormwater control center.

A catchment-wide network of rainfall and water level stations has been installed to feed data into the FDS. Inside FDS, a suite of programs combine to collect, exchange, process and analyse rainfall and water level data in real-time. Data is input into the hydrological and hydraulic modeling software which then forecasts the storm characteristic and predicts a potential flood situation within the first hour of storm and suggests an operation mode to the control center. The forecast by FDS is confirmed by SMART's human operators before diversion operations are executed.

Modes of Tunnel Operation

The SMART system is operated based on the predicted discharge of the Klang river just downstream of the Klang-Ampang river confluence. Guided by the FDS, the SMART Control Centre at the Klang-Ampang confluence confirms the prediction and initiates the three storm-situation modes for the tunnel. In normal mode (Mode 1) when flows do not exceed 70 m3/s, the entire flow is allowed downstream the city and the motorway section is open to traffic. Mode II is activated when the river discharge at Klang-Ampang river confluence exceeds

Dual deck motorway tunnel concept



70 m^3/s. Only 50 m^3/s will be allowed to flow into the city while the excess water will be diverted into the holding pond. The road tunnel will still be opened to traffic as only the stormwater section of the tunnel will be used to convey the stormwater.

When a major storm occurs in the catchment and FDS forecasts that the Klang River discharge will exceed 150 m^3/s, Mode III is activated and traffic will be evacuated from the road tunnel and it will be closed to traffic. In this mode, only 10 m3/s is allowed to flow downstream into the city center while the excess water is diverted into the tunnel. If the storm duration is brief and flows can be contained within the stormwater section, the motorway tunnel will not be flooded. The flood gates at both ends of the traffic tunnel compartment will be opened in preparation to receive excess flood waters. The tunnel will then be re-opened to traffic within 2 to 8 hours after closure.

If FDS predicts that the storm duration is long, Mode IV will be activated and the motorway tunnel will be used for flood water discharge. After the event has passed, the motorway tunnel will normally be closed for duration of 4 days to allow for cleaning and maintenance works. It will then be reopened to traffic following inspections and clearance by the Malaysian Highway Authority.

Performance and Impact

Since its commissioning, SMART has performed 203 diversions of which 5 were Mode IV events. These events were of magnitude similar to the benchmarked flood events of 2002 and 2007 which inundated the city for 3 days causing direct and residual damages of up to USD 3 million. SMART has won several engineering and construction awards and has been featured in the Discovery Channel. It remains the first stormwater and road tunnel in the world and an icon of Malaysian engineering and construction.

2013 IAHR AWARDS

Honorary Membership

Willi H. Hager
In recognition of his outstanding achievements in many fields of hydraulics both in his own country and internationally, his devoted service over many years to IAHR and, in particular, for his dedicated efforts as Editor of the Journal of Hydraulic Research and Council Member of IAHR.

Wolfgang Rodi
In recognition of his outstanding achievements in turbulence modelling and its application to hydraulics and hydro-environment engineering and his continuing support for IAHR through his high quality papers and monographs.

Nobuyuki Tamai
In recognition of his outstanding achievements in river engineering and continuing education both in his own country and internationally, and his devoted service to IAHR in many capacities and in particular as President of the Association from 2005-2009, and most recently as the Chair of the 2013 Council Election Nominating Committee.

4th M. Selim Yalin Lifetime Achievement Award

Yasuyuki Shimizu
for outstanding science and excellence in teaching and mentorship of young professionals as well as contribution to applied projects.

18th Arthur Ippen Award

George Constantinescu
for outstanding contributions in the field of fluid mechanics and especially of turbulence modeling with applications to fluvial hydraulics and stratified flows. To download the presentation scan the QR-code or see *http://tinyurl.com/p2z4hnr*

17th Harold Jan Schoemaker Award

Valentin Heller
for the most outstanding paper published in the Journal of Hydraulic Research during the period 2010-2012 entitled “Scale effects in physical hydraulic engineering models”, 2011, 49(3), pp293-306

Heidi Nepf
for the most outstanding paper published in the Journal of Hydraulic Research during the period 2010-2012 entitled “Hydrodynamics of vegetated channels”, 2012, 50(3), pp 262-279.

11th John F. Kennedy Student Paper Competition

First Prize
Sylvie Van Emelen, Catholic University of Louvain, Louvain, Belgium
For Paper Erosion Modeling over a Steep Slope: Application to a Dike Overtopping Test Case

Second Prize
Rafael Duarte, Laboratory of Hydraulic Constructions (LCH), Ecole Polytechnique Fédérale de Lausanne, Switzerland
For Paper Air Conc. in Plunge Pools due to Aerated Plunging High-Velocity Jets and Dynamic Pressures in Underlying Fissures

Third Prize
Mengzhen Xu, Tsinghua University, Beijing, China
For Paper Experimental Study of Bio-fouling Control of Golden Mussels (Limnoperna Fortunei) in Water Transfer Tunnels (China)

2013 Willi H. Hager JHR Best Reviewer Award

Stuart Cameron, University of Aberdeen, UK
for outstanding reviews during the period 2010-2012

Oscar Castro-Orgaz, Instituto de Agricultura Sostenible, Spain
for outstanding reviews during the period 2010-2012

Stefano Pagliara, University of Pisa, Italy
for outstanding reviews during the period 2010-2012

2013 JRBM Best Paper Award

Hans C. Komakech, Pieter Van der Zaag, Marloes L. Mul, Tulinumpoki A., Mwakalukwa & Jeltsje S. Kemerink (2012): "Formalization of water allocation systems and impacts on local practices in the Hingilili sub-catchment, Tanzania", International Journal of River Basin Management, 10:3, 213-227

2013 Heritage Award

Dujiangyan irrigation System, China
This is an irrigation infrastructure built in 256 BC during the Warring States period of China by the Kingdom of Qin. It is located in the Min River in Sichuan province, China, near the capital Chengdu. It is still in use today to irrigate over 5,300 square kilometers of land in the region.

35th IAHR WORLD CONGRESS

The Wise find Pleasure in Water

September 8 to 13, 2013 Chengdu China

成都

2013 Council Report

Financial Report for 2012

The IAHR Council at its Chengdu meeting 6-7th September approved the accounts of the association as audited by Ernst & Young which show a net loss for 2012 of €18,783 compared with a surplus in the previous year of €14,559. This loss was expected and was largely related to the high costs borne during the year for the development of the new Association Management System and exceptional accounting and auditing costs for the 2011 audit and which were borne in 2012. Total operational revenue for the year was €351,446 for 2012 and our balance sheet on December 31st 2012 showed assets of €523,408.

Business Plan and Budget for 2014

The IAHR Council approved the 2014 Business Plan and Budget. Membership Fees for 2014 will be increased by 1.8% to reflect inflation in Spain which is the location of the Secretariat.

Individual Member Fee Rate (2014): €79
(€39 in Lesser Developed Countries)
Junior / Senior Fee Rate (2014): €39 (€20)
Lifetime Members Fee Rate (2014): €238 (€119)

NB IAHR also offers special discounted rates for Student Chapter members and members of national associations

The 2014 Business Plan sees a focus on various key activities including:

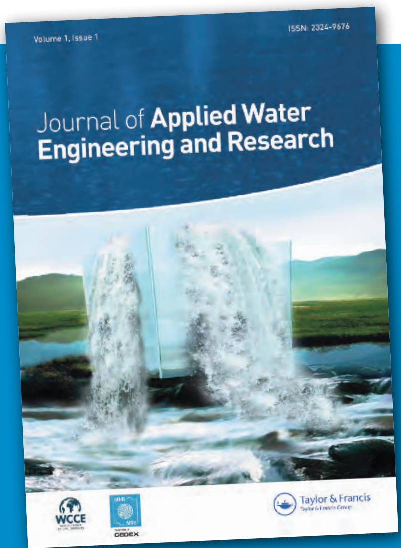
- More benefits for engineers working in practice - more-practice oriented Hydrolink magazine and our new Journal of Applied Water Engineering and Research (JAWER)
- Implementation and population of our new Association Management System
- Launching of a new Spanish-language Journal
- Strengthening of the regional congresses in Europe, Latin America and Asia Pacific
- Preparations for opening a new office in Beijing

Kuala Lumpur is chosen for the 2017 IAHR World Congress!

Two candidate cities were short-listed (out of four bids received) by the Executive Committee for the IAHR World Congress in 2017; after presentations and detailed discussion in the Council in Chengdu a difficult final decision was made in favour of Kuala Lumpur. However, the other short-listed bidder - Panama - was also considered attractive, and subject to some conditions Council is expected to confirm next year the award of the 2019 Congress to Panama.

IAHR to Open New Secretariat in Beijing

The IAHR Council has approved a proposal to open a new Secretariat for IAHR in Beijing from 2015. This will be located within the offices of our long-standing Institute Member IWHR (which is the Institute for Water and Hydropower Research of the Ministry of Water Resources). The Spanish Government has also expressed its desire to continue to host the Spain office after 2015 and this offer has also been accepted in principle. Discussions will shortly start on setting up this "twin Secretariat" operation – which will allow us to improve our service to members!



JAWER was launched in Chengdu

IAHR Publications News

The first issue of our new more practice-oriented Journal of Applied Water Engineering and Research (JAWER) was launched at a special launch seminar during the Chengdu Congress! JAWER is a joint venture with the World Council of Civil Engineers and Taylor & Francis and complements our existing more scientific Journals! All papers in this first issue are Open Access – visit the IAHR website for more information – and future issues will included as a member benefit! At the time of going to press the most viewed paper was "Simplified hydraulic modelling in model predictive control of flood mitigation measures along rivers" by Rodolfo Alvarado Montero et al! The next most popular papers are one on the design of the new Panama Canal locks, and a paper on the design of rip rap protection of bridge piers!

The new IAHR website is now operating and is the last part of our new Association Management System to be operational. We will be turning our focus in the coming months on developing content and using it to strengthen our technical committee activities!

Council approves new "Young Professional Network" scheme to build on the success of the IAHR Student Chapters!

The IAHR Student Chapter system was established in 2000 under the patronage of former Presidents Helmut Kobus and Forrest Holly with the first groups being founded in their own universities: Stuttgart and Iowa respectively. Since then it has grown to 27 registered groups with over 650 student members all over the world! Over 400 students attended the recent Chengdu Congress which included a series of special activities organised by the student leaders themselves.

The IAHR Council has been reviewing the success of this project under the leadership of Vice President Marian Muste with the strong backing of IAHR President Roger Falconer and has approved the establishment of "Young Professional Networks (YPNs)" which will incorporate and develop the current Student Chapter system. The new scheme is designed to bring together students, other researchers, engineers in practice and administration living within one city or region under the one umbrella – and using the university as focal point and catalyst for innovation! The aim of the new scheme is to catalyse greater collaboration between research and practice and encourage graduating students to stay within our community! IAHR will be offering very attractive discounted fees for Young Professionals who belong to a YPN! *For more information on this new scheme visit our website or contact Elsa Incio in Madrid at membership@iahr.org!*

The Council has also approved a new younger member fee category starting in 2014 which will be 50% of the normal fee rate!

Constitution Change

The IAHR General Members Assembly in Chengdu approved a change in the IAHR constitution – circulated earlier in the year as a proposal to all members - which sets the normal term for elected members at four years – this change regularises the previous practice of automatically re-electing council members for a second term! This change does not apply to the President, the three Vice Presidents and the Secretary General who continue to be elected for a two year period!

Some highlights from the Congress

JIAO Yong, Vice Minister of Water Resources of P. R. China

Keynote Speaker Tomás A. Sancho, President of the World Council of Civil Engineers and General Manager of SERS, Consultants in engineering and architecture

IAHR President Roger Falconer

2013 Chengdu Forum of International Water Organizations

Global Water Security Declaration

Water scarcity is on the rise

Water resources, people and economic activities are unevenly distributed around the world, which makes freshwater scarce in many areas. Water scarcity in most arid and semi-arid areas is intensifying with time, due, in large measure, to population growth and economic activity. Many parts of the world face water scarcity due to the lack of adequate water resources, human and institutional capacities to adequately govern and manage water and/or the economic means to develop water resources. The Global Risks 2013 report of the World Economic Forum identifies the water supply crisis as one of the two most likely high-impact risks of current times.

Water security means minimizing water related risks

Water security can be defined as the capacity of a population to safeguard access to adequate quantities of water of acceptable quality for sustaining human and ecosystem health, and socio-economic development and to ensure efficient protection of life and property against water related hazards (floods, landslides, land subsidence) and droughts. Hence, water security is the assurance of uninterrupted water supply in sufficient quantity and adequate quality to meet the water needs of domestic water consumption, food production and water-dependent economic activities that are essential for the welfare of a community, and in conformance with the principles of sustainable development. Globally increasing demand and competition for limited water resources, including groundwater, has drawn increasing attention to water security. Climate change has also accentuated the need for managing hazards associated with extreme hydrologic events, such as floods and droughts, but also to increase the reliability of the supply for all uses, including the environment.

Water security hinges upon balancing water supply and demand, both of which change over time, and avoiding the unsustainable over-abstraction of water. The supply of water can decrease due to the depletion of non-renewable water resources or degradation of water quality, climate change, or various other anthropogenic activities such as land use changes that affect the hydrologic cycle, such as land use changes. Water supply can increase through the development of new water resources. Water demand can increase as a result of population and economic growth. It can be managed through conservation, increased water use efficiency, economic measures, and agricultural and trade policies and practices. Achieving the optimal equilibrium between water supply and water demand, without compromising future water security, is the central goal of water management. Achieving this goal requires adequate human and institutional capacities, as well as cooperation between stakeholders at the local, regional and international levels.

Demand management is essential for water security

The Integrated Water Resources Management (IWRM) approach has now been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands. In general, water supply augmentation is challenging and often not an option. Many countries and regions, other than sub-Saharan Africa, facing water scarcity have already fully developed their water resources beyond sustainable levels, resulting in rivers running out of water by the time they reach the sea, lakes shrinking in size and groundwater wells running dry. Non-conventional ways to augment the water supply include recycling, desalination and, at a small scale, water harvesting. Theoretically, desalination offers the potential of unlimited water supply to areas near the ocean, or other saline water bodies, but its feasibility depends on the availability and cost of energy which remains high, despite technological advances in membrane technologies based on reverse osmosis. In many areas, demand management offers the only viable solution for sustainable development. Demand management aims at influencing attitudes and consumption patterns towards more efficient and cost effective water use. It is often practiced through a combination of economic, technical and administrative measures, with educational and social interventions also playing a role. Economic measures include valuing and pricing mechanisms and other incentives for reducing water use. Technical measures include conservation and increasing water use efficiency and water reuse. Adopting such measures is critical for the viability and community acceptability of new projects built in parts of the world where water is scarce.

In parallel with demand management, the sustainable use of existing and future water supply infrastructure, where reservoirs and dams play an important role, is essential for water security, especially in developing countries, and to face global challenges associated with increasing demand due to population growth and climate change. Governance, maintenance and sedimentation management are key issues for securing adequate water supply in the future.

In developing countries, the need to speed up the development of water storage and sustainable water related infrastructures is of utmost importance, to address the critical need for water supply, energy, food production and sanitation, but it must be pursued in according with the principles of sustainable development. In many countries of the sub-Saharan Africa, the real use of renewable water is less than 10% of the known potential due to a lack of investment for water storage and water supply infrastructure, which is worsened by the rural characteristic of these regions.

In 2050 the world population will reach nine billion, with a corresponding increase in the demand for water, food and energy which will double impacting on the need to speed up and augment water storage infrastructure development worlwide.

Several factors threaten water security

Several factors threaten water security or make its future status uncertain. Such factors include:

- *Population and economic growth, including urbanization and land use change;*
- *Lack of water resources mobilization and appropriate water supply infrastructure in some developing countries;*
- *Unsustainable water use, often driven by poorly thought-through development goals;*
- *Inefficient and wasteful water use;*
- *Climate change.*

We, the undersigned associations, therefore call for joint action to improve global water security

Policy. *There is an urgent need to increase cooperation on water by working together and with other global organizations, such as UNESCO, FAO, the Global Water Partnership and the World Water Council, to inform policy makers about current and emerging threats, and promote solutions and strategies to ensure water security.*

Education. *Promote formal education on water issues at all levels and raise capacities among key stakeholders and the general public. Academic and association members will be encouraged to contribute to the strengthening of educational systems, including curricula and teaching materials that would serve this goal. The concepts of virtual water and the water footprint can be used to help the public better understand the impact of everyday choices on global water security.*

Research. *Promote thematic research (including the development of modeling techniques) in areas including climate / land / surface water / groundwater interactions, monitoring systems and methods for water management, increased water use efficiency in domestic appliances, industrial equipment and processes, and agriculture; water recycling and reclamation and management of the byproducts formed during the management of the water cycle.*

Practice. *Engineers and other professionals can contribute to greater water security through the design of sustainable hydro-environmental systems, including enhancing water use efficiency in agriculture and industries, such as power generation, mining, and oil and gas production and processing.*

We endorse the above principles and commit to collaborating with all partners and stakeholders that share this common vision.

Approved on the 9th of September 2013 in Chengdu, China.

Signed on the occasion of the 35th IAHR World Congress by:

International Association for Hydro-Environment Engineering and Research (IAHR)

International Commission on Large Dams (ICOLD)

International Commission on Irrigation and Drainage (ICID)

World Association for Sedimentation and Erosion Research (WASER)

World Council of Civil Engineers (WCCE)

International Water Resources Association (IWRA)

International Association of Hydrological Sciences (IAHS)

United Nations Secretary General's Advisory Board on Water and Sanitation (UNSGAB)

In the presence of UNESCO's Natural Sciences Sector

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PEOPLE & PLACES

Roll of Honour

- **Tony Comerio**, Hanson Professional Services Inc., United States of America introduced by Mr. William Rice, United States of America
- **Zhiguo He**, Zhejiang University, China introduced by Prof. Weiming Wu, United States of America
- **Hao-Che Ho**, Zhejiang University, China introduced by Prof. Marian Muste, United States of America
- **Jannik Haas**, Chile introduced by Eng. Diego Arce Morán, Chile
- **Eduardo Yassuda**, Tetra Tech, Brazil introduced by Prof. Dr. Tobias Bleninger, Brazil
- **Mike Miloshis**, Charles Darwin University, Australia introduced by Prof. Eric Valentine, United Kingdom
- **Olivier Delestre**, University of Nice Sophia Antipolis / UNSA, France introduced by Prof. Philippe Gourbesville, France
- **Rémi Dumasdelage**, France introduced by Prof. Philippe Gourbesville, France
- **Bert Geerken**, TU Delft, Netherlands introduced by Prof. Arthur Mynett, Netherlands
- **Julio Masís-Jiménez**, Rivering de Costa Rica S.A., Costa Rica introduced by Prof. Shoji Fukuoka, Japan
- **Matthew Wood,** HR Wallingford, United Kingdom introduced by Prof. Dr. Tobias Bleninger, Brazil
- **Juan Chen,** China introduced by Yuan Shi, China
- **Ozeair Abessi**, Iran University of Science and Technology, Iran introduced by Prof. Dr. Tobias Bleninger, Brazil
- **Gonzalo Javier Olivares Cerpa**, Instituto Flumen, Universitat Politècnica de Catalunya, Spain introduced by Manuel Gómez Valentín, Spain
- **Eduardo Martínez-Gomariz**, Instituto Flumen, Universitat Politècnica de Catalunya, Spain introduced by Manuel Gómez Valentín, Spain

A sad moment

Yoshiaki Iwasa
(1929-2013)

Yoshiaki Iwasa, Professor Emeritus of Kyoto University, passed away on March 20, 2013. He made great efforts for the development of IAHR as Vice-President from 1986 to 1990, and was Chair of the Local organising Committee of the 25th IAHR World Congressheld in Tokyo in 1993. For full information to go www.iahr.org under the section “About IAHR>Obituaries”

Frank Molkenthin has been very active in setting up the highly successful IAHR supported web-based education project called “HydroWeb” between 1999- 2014 in collaboration with prof Andre van der Beken, and with the new IAHR Student Chapter network and EGW with the support of former IAHR President (and Hon. Member) Helmut Kobus. In 2003 this ground-breaking project had 108 students from 14 universities in 12 teams!

Since 2003 Dr Molkenthin has been a partner in the EuroAquae project set up by former IAHR VP Philippe Gourbesville. In his new role Frank is interested in developing again a new web-based education initiative with our Student Chapters

Prince Sultan Bin Abdulaziz International Prize for Water, Saudi Arabia

PSIPW aims to give recognition to the efforts that scientists, inventors and research organizations around the world are making in water related fields. PSIPW acknowledges exceptional and innovative work which contributes to the sustainable availability of potable water and the alleviation of the escalating global problem of water scarcity.

For this reason, PSIPW awards a suite of five bi-annual prizes, covering the entire water research landscape. December 31 is the deadline for receiving nominations for the 2014 Award!

Erratum

In the article "The Need for a Water/Energy Synergy in a Thirsty World" by Jose Luis Gonzalez Vallve, Chief Executive Officer of AGA, Spain, the word "approach" was missing at the end of the article.

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