A NEW PARADIGM FOR R&D IN WATER RESOURCES ENGINEERING

UN NOUVEAU PARADIGME POUR R&D EN GENIE HYDRAULIQUE

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ABSTRACT

The technology in WRE seems to be stagnant. No new technology of any significance has emerged for quite some time now and there seems to be none in the pipeline. In the WRE sector, R&D does not generate the same level of excitement and challenges that it does in other sectors. Shortage of funds does not seem to be the cause for this disappointing performance of R&D. The main problems are :

- WRE R&D has very little potential for patents, **I**ntellectual **P**roperty **R**ights (**IPR**s) and profit and therefore private sector does not take interest in R&D in WRE.
- Most of the research pursued by the universities is too theoretical. There is very little applied research.
- There is a marked lack of creativity and inspiring ideas for R&D. There are neither any "technology dreamers" nor any dreams.
- The users are not being involved in the planning.

The time is running out for R&D managers in WRE. The vision plans of most governments incorporate a set of measurable performance targets to be achieved in a stipulated time frame. Many of the targets are less than 10 years away. Therefore, if the R&D is to be of any assistance in achieving the targets set for AD 2010, then that R&D must start NOW, not next year. The present approach to the R&D has not produced desired results and therefore, it must be changed immediately.

The paper proposes a new approach to provide an impetus to R&D in WRE sector.

RESUME

Il apparaît que la technologie du génie hydraulique est dans un état stagnant. Aucune nouvelle technologie significative n'a émergé depuis un certain temps, et il semble qu'il n'en existe aucune. Dans le secteur de génie hydraulique, le domaine de

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recherche et de développement ne suscite pas d'enthousiasme et ne pose n'ont plus de défis comme dans d'autres secteurs. Le manque de fonds ne semble pas être la cause principale de cette malheureuse performance du domaine de R&D. Les principaux problèmes sont les suivants :

- Le domaine de R&D du génie hydraulique a très peu de potentiel pour le brevet, et le secteur privé ne manifeste pas un intérêt accru à ce domaine.
- La plupart des travaux de recherche entrepris par les universités sont de nature trop théorique. Il y existe très peu de recherche appliquée.
- Le manque de créativité et des idées inspiratrices dans le domaine de R&D est très évident.
- Les usagers ne sont pas impliqués dans la planification.

Il est à remarquer que le temps fuit sans que les gestionnaires du domaine de R&D du génie hydraulique ne pouvant contribuer davantage à ce domaine. Le plan de vision de la plupart des gouvernements comporte une série de cibles de performance mesurable à atteindre dans la limite du temps prévu. La plupart de ces cibles portent sue une période de moins de 10 ans. Par conséquent, si le domaine de R&D doit atteindre objectifs prévus pour l'année 2010, ce domaine de R&D doit commencer à démarrer dès maintenant et non l'année prochaine.

Les approches actuelles dans le domaine de R&D n'ont pas donné des résultats escomtés, et par conséquent, des changements devront être envisagés dans ce domaine. Le rappport propose une nouvelle approche pouvant donner de l'encouragement et d'incitation au domaine de R&D du génie hydraulique.

SUMMARY AND CONCLUSIONS

The technology in WRE seems to be stagnant. No new technology of any significance has emerged for quite some time now and there seems to be none in the pipeline. The main problems are: WRE R&D has little potential for patents and profits and therefore, private sector takes no interest in WRE R&D; research pursued by the universities is too theoretical; there is a marked lack of creativity and inspiring ideas for R&D and the users are not being involved in the planning.

Time is running out for R&D managers. Vision plans of most governments for the development of their nation's water resources incorporate a set of measurable performance targets to be achieved in a stipulated time frame. Many of the targets are now less than 10 years away. The present approach to the R&D has been given more than sufficient time to prove itself. Since, it has not produced desired results, it must be changed immediately.

It is unlikely that useful R&D will be done in Government institutions. Once there is an idea, exploring it is a matter of hard work. But the birth of a new idea itself needs considerable creativity, an ability to dream and Government departments do not

provide the necessary fertile environment that encourages creativity. Career related job shifts and transfers for administrative reasons disrupt continuity. R&D is not a very rewarding career pursuit and therefore the best of the talent is not attracted to R&D.

Therefore, successful R&D will have to come from the academic institutions or private institutions. The onus of directing the energies of academicians towards useful, applied research is with the R&D managers in the Government. Likewise, the onus of providing incentives to private sector to take up R&D is also with the Government. Since R&D in WRE has very little potential for generating patents and profits, the usual incentives like tax benefits are of little use. Private institutions need to be invited to take up R&D as a consultancy project where Government reimburse not only the entire project expenditure but also a reasonable profit. To do that, the government departments need to accept that R&D is a symbiotic activity where all participants have something to gain. They must shed their philanthropist airs.

Governments departments in water sector need to accept that management of R&D is as much a specialized task as is designs or flood forecasting and place capable individuals in position to manage the R&D.

The stress should be on research driven by demand rather than pursuit of esoteric ideas. The concept of “thrust areas” should be discarded and specific technology goals should be identified and entrusted to especially created “technology missions”.

R&D managers must open a communication channel with possible users of R&D to understand their needs.

Formulation of R&D projects needs greater attention than what it gets now as incorrect formulation is sufficient to guarantee useless results.

Government officials on the research committees are nominated in their ex-officio capacity. It is not possible that any and all government officials are competent to guide research. The role of the individual needs to be recognized. Persons who have an aptitude for creative thinking should be identified and involved in research planning. A spirit of competition needs to be encouraged amongst several research groups.

The model proposed at length in the paper may be given a trial for a few areas. Its performance should be evaluated over next three years and if it shows signs of better performance then it may be adopted on a larger scale.

1. PERFORMANCE OF R&D IN WATER SECTOR

The ICID bulletin “Call For Papers” introduces the special session on R&D in irrigation, drainage and flood control with a paragraph that is a severe indictment of

the performance of R&D in this sector. An extract from this paragraph is reproduced below for ready reference.

> "*Water research, especially in the developing countries, has not been able to attract the same level of financial and institutional support as agricultural research. In most of these countries, water research is carried out primarily by public institutions. By and large, universities have not made very significant impacts on improvements in performance of the water sector. Further more, the private sector has not played any major role in the water research. For the most part, research institutions are not driven by a strong peer review, and competitive culture. This has often lead to complacency and weak institutional performance."*

It is a good thing that the ICID, on behalf of water engineers' community, has acknowledged that the performance of R&D in **W**ater **R**esources **E**ngineering (**WRE**) during recent past is far from satisfactory. It saves the need for lengthy arguments and case studies to establish this as a fact. This assessment of R&D is true not only for the three specific sub-disciplines identified for the special session – irrigation, drainage and flood control – but is also true for other sub-disciplines *viz*: hydraulics, hydrology, geo-technical engineering, structures etc.

However, in singling out the universities and private sector for the poor R&D work, the paragraph gives an impression that the R&D scenario in irrigation and drainage is satisfactory but there is a localized problem in certain type of institutions and in developing countries. It is possible that this impression was not intended but in case it was, then it needs to be stated that the R&D scenario in WRE sector is disappointing in general and is not restricted to universities and private institutions alone. Further, it is also not the case that excellent R&D work is going on in developed countries. Consider following indicators :

- In all other sectors, starting with simple devices like the pen or the radio receiver to complex devices like computers or aircrafts, there has been a *visible change* in the technology during past few decades. The micro-tipped pens of today are a distinct improvement over the ballpoint pens of last decade which in turn were a marked improvement over the ink-filled fountain pens of 20 years ago. Same is true for other sectors, be it automobiles, electronics, fabrics, medicines….whatever. In contrast to this, the technology in WRE seems to be stagnant. No new technology of any significance has emerged in the WRE for quite some time now.

- In all other sectors, the specialists discuss the future scenario in *quantitativ*e terms and also *qualitative* term. e.g. asked about the future of civil aviation, an aircraft engineer can discuss the likely growth in passenger traffic, growth in demand for aircrafts, etc. which is *quantitative*. But, he is also able to discuss the safer and better aircrafts, or the more efficient engines that are expected in near future and that is *qualitative*.

The qualitative projections are based on the knowledge of what is there in the R&D pipeline. The era of innovators surprising the world with new inventions is over long ago. Now-a-days, any new technology is clearly visible over the horizon well before it actually "arrives". As it comes closer, even the time of its arrival can be predicted pretty accurately.

In contrast to this, the WR engineers speak only in *quantitative* terms, the increase in storage capacity, additional area to be brought under irrigation etc. They are unable to speak in *qualitative* terms because the status R&D pipeline in WRE is not known. No one has a clue about what new technologies are expected and when.

- In most other sectors, R&D is an *exciting* field where R&D personnel are competing against each other to be the first one "to get there"; to outdo each other. In contrast to this, in the WRE sector R&D is a staid branch where nothing much seems to be happening. The technology goals are not clearly defined and therefore the question of competition to reach those goals before others do, does not arise.

It should therefore, be appreciated that the R&D scenario in WRE sector is a lot worse than what it seems to be and the WR engineers have to take a hard look at themselves to examine the reasons for this poor performance. Only, then an appropriate remedial plan can be evolved.

2. INGREDIENTS AND PLAYERS IN AN R&D PROGRAM

Funds

A comparison of the expenditure on R&D in WRE with that in the agricultural sector or any other sector by itself does not indicate whether the funds available are sufficient or not. The adequacy or otherwise of the funds should be judged solely by the criteria whether any research projects were held up for want of funds. It has been the experience that often the funds earmarked for R&D in a financial year are not fully spent. Moreover, National Committees for Irrigation and Drainage often fund R&D projects that are more in the domain of agronomy than WRE. Therefore, the WRE sector cannot complain of lack of funds.

Private sector

The private sector has not played any major role in R&D in WRE, and for obvious reasons. The only source of funds for the private sector is the profits generated through commercial activity. Therefore, private sector will take up R&D only in such areas as will enable it to recover the expenditure on R&D through intellectual property rights, by developing a commercial, profit-making products or through royalties.

Private sector spends billions of dollars on research in new medicines or in new vaccines because the new drugs can be patented and the patents can be exploited for making profits. But, the research for new surgical procedures takes place only in medical colleges because a new surgical procedure can not be patented and does not offer any potential for making money. Most of the R&D work in WRE is similar to this later category. It does not result in a tangible product or a process that can be patented and therefore lacks the potential to make profit. Therefore, private sector's lack of interest in R&D in WRE is for valid reasons and will remain so.

Universities

While it is true that universities have not made any significant impact on improvements in performance of water sector, the reasons for this may turn out to be far more complex than what appears at the surface. Is there any complacency on part of the universities? Interacting with the academicians during seminars, workshops and research committee meetings, one gets the feeling that the academicians are quite satisfied with their R&D work. They do not seem to be even aware that their work does not address the "urgent problems now confronting the water sector".

It is not as if the universities have not been taking sufficient interest in R&D in WRE. The problem is that most of the research pursued by the universities is basic research and there is very little on the applied side. Therefore, a more appropriate charge against the academicians would be of pursuing esoteric topics rather than being complacent. For the purpose of this paper, basic research is defined as that where one tries to improve one's understanding of the nature without any direct reference to the technology as it is practiced. Applied research is that where the present understanding of the nature is used to improve an engineering practice.

A workshop on "Management of R&D" was conducted at Pune, India, November 2001. In this workshop an eminent academician was invited to analyze this issue of role played by the universities in R&D in WRE and specifically the charge that universities have been pursuing topics that are too theoretical. While he outlined the R&D work carried out by the universities, he also neatly turned the tables back on practicing engineers by asking them to list instances where they have asked the universities to take up a particular applied research and the universities have refused or failed to rise to the occasion. So the question reduces to, "do the practicing engineers WR field know what exactly they want ? Do they have clear goals ?"

This is an important question. Universities expect the practicing engineers to specify the research needs, particularly in the context of applied research. If the practicing engineers have not specified their needs then the academicians can not be blamed for confining themselves to basic research. Most of the funding for R&D in WRE comes from Government and the R&D proposals from universities are critically examined by the R&D managers in the Government before these are approved for funding. Therefore, the responsibility for not specifying applied research needs and then allowing the academicians to indulge in purely basic research, will have to be accepted by the practicing engineers in the field and in the Government.

Inspiring ideas

Having exhorted the universities to address the urgent problems now confronting the water sector, it becomes incumbent upon the R&D managers to define precisely what research projects must be taken up to solve these urgent problems. A statement of the problem does not automatically lead to the formulation of research projects that will solve the said problem.

This is an important point and needs to be elaborated with an analogy. Increase in air pollution due to automotive emissions was, and continues to be, an urgent problem confronting the city administrations all over the world. But, there is no such thing as "taking up R&D to solve the urgent problem of reducing the pollution of air by automotive emissions". Someone had to come up with possible ideas on how exactly to reduce the pollution. The "dreamers" in the auto industry came up with ideas such as inventing new fuels that would cause less pollution; improving the combustion by redesigning the carburetor; removing a part of the offending gases from the cocktail of exhaust gases by a chemical reaction; and so on. These ideas formed the core of R&D projects which, in due course, resulted in new fuels (gasohol); replacement for the carburetor (**M**ulti-**P**oint-**F**uel-**I**njection system); chemical agents for cleaning up exhaust gases (catalytic converter); etc.

Now that these improvements are in common use, it seems these were very obvious things to do. But, there was a time when carburetor was the only known device for injecting fuel-air mixture in to the cylinder of a petrol engine. It must have required considerable creative thinking on some one's part to conceive what we now know as a MPFI system. **This creative thinking is not a part of a research project. It is a step that gives birth to a research project**.

In the context of R&D, a remark by the well known inventor Thomas Alva Edison that "invention is 99 % perspiration and 1 % inspiration" is quoted often. What Edison probably meant was that it needs a lot of hard work to develop an idea into a usable device. Whether the role of inspiration is just 1 % or more is a matter of debate but, there is no denying that without the inspiration, just the perspiration would be of no avail.

It is a misnomer to say that R&D solves a problem. R&D is an activity that brings a solution from the realm of a dream to the realm of reality. R&D makes a solution "possible", but to do that someone has to first "see" the solution while it is still beyond the horizon, in the realm of a dream.

It is the present author's contention that during past few decades, the water engineers have displayed a remarkable lack of capacity for creative thinking, or dreaming. Therefore R&D in WRE presently comprises close to 100 % perspiration with almost no inspiration. As a result the development of technology in WRE has come to a standstill.

The onus of "dreaming" the solutions is on both, the technocrats and the academicians. The formers are more aware of what is practical "out there in the field" while the latter are more familiar with what is feasible in terms of technology. However, technocrats also ought to have some idea what is feasible in terms of technology. Unless, they are so familiar, they will be unable to guide the research in the right direction. Likewise, the academicians also need to be familiar with the field problems. When they lose such contact, they tend to indulge in esoteric pursuits.

The last lap, laboratory to field

One of the reasons R&D in agriculture has shown better results could be because agricultural research is conducted in fields rather than in labs. Through experimental farms, through agricultural extension programs and, in India, through the network of *Krishi Vigyan Kendras* (Centers for Agriculture Sciences) the agronomists have maintained a good contact with the field. Asked to investigate a new technique for reducing evapo-transpiration, the agricultural scientist typically wants to conduct the experiment in an experimental plot a few hectares in size. But, his counterpart WR engineer, asked to investigate a new technique for reducing evaporation from water bodies typically wants to conduct the experiment in a Class A evaporation pan.

Within WRE also, useful work has been done when universities have maintained a contact with the users of R&D. e.g. the **I**ndian **I**nstitute of **T**echnology (IIT) Delhi has done some useful work in flood forecasting because of its interaction with Central Water Commission's flood forecasting organization. In the foregoing statement, the emphasis is on *useful* nature of the work and **not** on *pioneering* nature of work.

Involvement of users

This leads to the issue of involvement of R&D users. Preferably an R&D program must be formulated in consultation with the R&D users. There are many well documented studies which indicate that R&D programmes taken up to the exclusion of R&D user have a very high risk of coming out with a useless product. A well quoted example is that of picture-phone, where the two conversing persons can see each other's picture also. The technology of picture-phone was successfully worked out. But, as subsequent investigations revealed, there were several reasons why people did not want the person at the other end to see their picture. As a result, the invention, though successful in technology, had no takers.

An R&D program has three main constituents. The R&D managers, the R&D workers and the R&D users. The users of R&D in WRE consist of technically illiterate farmer at one extreme, technically qualified operation and maintenance engineers in the middle of the range and very highly qualified design engineers at the other extreme. The R&D managers comprise the technocrats in the Government and R&D workers comprise the academicians who undertake research. At present, the R&D programs are proposed by the R&D workers (academicians) and are examined

and approved by the R&D managers (technocrats). There is very little involvement – if any- of R&D users.

In all other fields, the interaction of R&D managers and R&D users is accepted as obvious. Medical researchers are in close contact with medical practitioners. Aircraft designers have test pilots on the design team. R&D managers of domestic appliances manufacturers also interact with the house-makers to understand what improvements are required in their washing machines. At least so they claim in their advertisements. However, in the WRE sector, this dialogue with the users seems to be missing.

Management of R&D

There is one more difference between the water sector and other sectors which is crucial and yet not easily appreciated. Other sectors view *management of R&D* as a specialty by itself. Water sector recognizes the importance of R&D, but does not accept the importance of *management of R&D*. WR sector administrators accept that designs of various structures, construction, dam safety, hydrology, flood forecasting, river morphology, irrigation, water management, drainage etc. etc. are all areas of expertise. But most people are not aware that management of R&D is also a specialized task and think that to head R&D unit is "just another posting" and worse, a part time activity.

3. TOWARDS A NEW PARADIGM

Time frame

The foregoing analysis indicates a few reasons as to why the R&D scenario in WRE sector is so uninspiring. Meanwhile, the time is running out for R&D managers. Most governments have drawn up a vision for the development of their nation's water resources. These vision plans incorporate a set of measurable performance targets e.g. storage creation, irrigated area, water use efficiency, productivity per unit area or per unit volume of water etc. to be achieved in a stipulated time frame. There was a time when the targets were in a distant time frame. With passage of time, the target dates are coming closer and now many of the targets are less than 10 years away.

In WRE domain, an R&D project typically takes 5 years or thereabouts to show results and it takes another few years for these results to be implemented in the field. Therefore, if the R&D is to be of any assistance in achieving the targets set for AD 2010, then that R&D must start **now**, not next year. The present approach to the R&D has been given more than sufficient time to prove itself. If it has not produced desired results, it must be changed and changed immediately. With this as the background, following suggestions are made towards a new approach for R&D in WRE.

Stress on demand driven research

At present, most of the R&D proposals originate with the academicians. Traditionally, the academic community is more comfortable with basic research and perhaps because of this, there is a preponderance of basic research to the detriment of applied research. Basic research is defined as that where the objective is to improve the understanding of natural processes. Applied research is that where the present understanding of natural processes is *applied* to improve the performance of the man-made systems. Basic research is about acquiring knowledge. Applied research is about applying that knowledge.

While basic research has its own place, engineering is all about applications. It should not be necessary to chose one out basic and applied research. But, if such a choice must be made, for whatever reasons, then it is the applied research that must get the preference.

Mission oriented approach

The concept of thrust areas should be discarded immediately. Instead, about 10 *technology development goals* should be identified. "Technology missions" should be constituted for each of these goals and these missions should be given necessary funds and some freedom and asked to pursue and achieve the specified goal within a specified time frame.

Management of R&D

The technocrats and administrators in the WR sector must first acknowledge that management of R&D is a specialized task by itself. This is a necessary first step that may lead to more capable individuals getting posted to manage R&D units. It is not the intention to take up in this paper the procedural problems being faced by the R&D units. If more capable individuals get posted to head R&D units then they will identify the problems in their respective units and come out with remedies.

Institutions for R&D

It is unlikely that useful R&D will be done in Government institutions. Some of the reasons are :

- Creative work flourishes in intellectually stimulating environment where focus is on doing work rather than on following rules and procedures. Government departments are not exactly famous for providing such an environment.
- Continuity is of utmost importance in R&D. But in government institutions, career related job shifts and transfers for administrative reasons are unavoidable. Engineers in government departments do not enjoy necessary continuity.
- In government departments, R&D is usually not the most rewarding career pursuit. Therefore the best of the talent is not attracted to R&D.

- R&D is much more demanding than routine work. An academician at least has some opportunities to convert his knowledge and reputation in tangible returns through career moves, consultancy assignments, participation in conferences and seminars etc. Officers in government departments do not have such opportunities and therefore lack the motivation to put in extra efforts.
- Government R&D institutions are more occupied with project related problem solving and have little time to focus on R&D.

Therefore, successful R&D will have to come from the academic institutions or private institutions. As already explained in the foregoing analysis, private institutions are not likely to be interested in R&D in WRE sector because it does not have the potential to generate profits. Therefore, if the academic institutions are not adequate for the task, private institutions may be invited to take up R&D on a payment basis where the entire expenditure for the project and a reasonable profit is reimbursed by the Government. For consultancy it is customary to involve private organizations on a cost + profit payment basis and there is no reason why the same model can not be adopted for R&D.

Involvement of users

The R&D managers must open a communication channel with the possible users of R&D to understand their needs. The interaction with the possible users must be maintained at all stages of R&D, viz. drawing up R&D plans; formulation of individual R&D proposal; mid-course review and final implementation. It is advantageous if the academicians also maintain such interaction with the end users. But, if they do not, the onus of interacting with the users rests with the R&D managers. Once the users are involved in the R&D planning, the emphasis of research will automatically shift towards applied research.

The members of the research planning committees should be given opportunity, should in fact be goaded, to visit the field and interact with the project custodians, farmers, NGOs and likes to help them appreciate the problems in the field and user requirements.

Symbiotic participatory approach

While there is no shortage of words in the praise of R&D, in reality the government departments who fund R&D work tend to see themselves as givers of aid. The realization that R&D is a symbiotic activity where all participants have something to gain, does not seem to have sunk in. The government departments need to shed their philanthropist airs.

To remedy this flaw, reputed institutions who have the potential to take up R&D projects and make a success out of it should be identified and inducted into the process of planing research projects. Research Planning Committees (RPCs) should be constituted comprising R&D managers, academicians from the identified and

participating institutes, and end users. The research projects should be planned and monitored by these RPCs.

Formulation of R&D proposal

The single most important change that is required is at the stage of formulation of R&D projects. Formulation includes iterative process of examination and modification of the R&D proposals. Utility or otherwise of an R&D project gets determined at the stage of formulation. Once the objectives and methodology are formulated, fate of the project is more or less fixed. Correct formulation of the objectives and methodology is therefore a necessary condition, but not sufficient condition, for obtaining useful results. Incorrect formulation is, however, sufficient to guarantee useless results.

At present, the academic institutes plan research projects in isolation and without any involvement of either the government or end users. The proposal is then submitted to the government who examines it and takes a decision on funding it. While so examining, the department officials often assume the role of jurors which they may not even be competent to assume. Even if there are no useful proposals, the allocated funds must be spent and therefore, some proposals must be approved. This invariably degenerates into funding the least useless proposals.

The participatory approach with RPCs mentioned in the foregoing paragraph, where all the players participate in planning of the research projects, should result in more useful proposals.

Importance of individual

Academicians are usually inducted in to research committees on basis of their individual reputation. On the other hand, government officials on the research committees are nominated in their ex-officio capacity. This amounts to saying that while only some academicians qualify to be on the research committees, any and all government officials are competent to guide research. This simply can not be true.

It is therefore necessary to discard the usual mould for constituting such committees and stress on individual rather than the office she/he is holding. Organizations responsible for R&D administration should carry out an exercise to identify persons who have an aptitude for creative thinking. The research committees should comprise of such spirited individuals irrespective of their place of posting. Once this approach is adopted, the individuals will not be disturbed by transfer/promotion and their continuity in research committees for longer periods will be automatically ensured.

Introducing competitive spirit

Within RPCs, smaller groups of four or five persons should be setup to handle different topics. A group should have the responsibility to formulate project ideas, obtain proposals from reputed institutes, examine these proposals and recommend them for final acceptance. It would be the responsibility of the group to defend their proposal before the body that takes a final decision on funding. The proposal should be owned - and proudly so - by the group that fathered the proposal and who is going to nurse it for the next few years till its completion. The group would also monitor the project till its completion. In other words, the group will be a chaperon for a project. There should be an annual comparative and hence competitive evaluation of the performance of various groups.

How to kick-start research is itself a topic for research. The proposed model may be given a trial for a few areas. Its performance should be evaluated over next three years and if it shows signs of better performance then it may be adopted on a larger scale.