Thermodynamics, Kinetics, Chaos and Communication

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Abstract

The world was simpler hundreds of years ago when creative bursts by a single individual had a massive impact on the technical progress of the human community. The world is more complex now and, as a consequence, everyone must be more attentive to developing capabilities and systems that foster communication among people. This is thought to be an easy task, but it is not. Effective communication is not easy. Significant intellectual and emotional energy must be invested in communicating. Specific examples are given of DEEP's activities in technology transfer of diesel emissions reduction testing.

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I want to talk about communication. We know it's important, sometimes even life and death hinges on it, as shown in this cartoon.

"Wait! Wait! Cancel that, I guess it say's "help." "

But I want to focus on more than spelling. Being a physical chemist, I am electing to come at it in a somewhat unconventional way. I want to put it in a thermodynamic context. Some of you may have had thermodynamics as part of your education, but others may have had little contact with it. Let me state some salient points.

There are actually four laws of thermodynamics which summarize what we know about the behaviour of processes involving thermal energy. The Zeroth Law says that heat flows naturally from a hot to a cold body. When I was dating my future wife many years ago, I took care to demonstrate this law to her any time I could. In Las Vegas language, this law means that the thermodynamic game is open and that you can either win, lose or break even. Upon further examination in the 19th Century, the 1st Law of Thermodynamics stated that energy is conserved in an isolated system. The consequence of this Law is that we can never win; we can only break even or lose. The 2nd Law of Thermodynamics says that Nature makes it very difficult to break even. The reason is that there is a physical quantity which always changes in the same way in all natural processes. Early workers termed that quantity "entropy"—which comes from the Greek meaning "evolving". Because entropy always increases in any spontaneous process, and is related to temperature, it turns out that the 2nd Law says it is possible to break even only if you are at absolute zero temperature on the Kelvin scale, which is –273 ºC. And, finally, the 3rd law says achievement of absolute zero is impossible. Therefore, we always lose. In thermodynamics, Nature always wins. Everything within Nature loses.

You may have heard of another way to express the Laws of Thermodynamics: natural processes always increase entropy and cause the universe to be one step closer to its final endpoint of total chaos. In fact, the question has to be asked: if all natural processes go to the most disordered or chaotic state, how is it that living beings exist at all? How can organized life forms have come into existence when everything is bent on becoming disorganized?

This question is beginning to be answered by Ilya Prigogine and his colleagues. The answer lies in irreversible thermodynamics where systems are operating far away from equilibrium. Prigogine won the Nobel Prize in Chemistry in 1977 for his work on natural self-organizing systems. His research has shown that systems far from equilibrium experience fluctuations that are so powerful that the system can enter another mode of behaviour—it can self organize. The result is that chaos can decrease in some portion of the system. The key here is the word "portion" because the totality of the system still obeys the march toward chaos.

Prigogine views that the evolution of life on this planet has not happened for biological efficiency. Rather, it has happened because of the far-from-equilibrium situation existing here due to a tremendously powerful nuclear fusion reaction happening about 92 million miles away. The situation here on Earth is far from equilibrium because of the temperature gradient that exists between the sun and us. As a consequence, macromolecules were formed from simpler components and these molecules found ways of coding information and communicating it through reproduction

We are, therefore, by our very existence, examples of decreased chaos. We are carriers of information (DNA) that allows chaos to be defeated in a small part of the larger universe. Human individuals have found it beneficial to have contact with other humans. The result is the creation of a society. We do this with much expenditure of energy so that common desires of safety, food, shelter and giving and receiving love are met. One of the main ways we fight the tendency toward chaos is by communicating with each other in a wide variety of ways, including gestures, facial expressions, art, music, mathematics, and written and verbal language. This expenditure of energy is the price we must pay to keep the ordered system going.

Some communication comes very naturally. And, as a result, we believe communication is easy. We learn to talk at an early age, but many of us never learn to listen. The acts of talking and hearing do not ensure communication. The root of the word comes from the Latin *communis*, meaning “that which is held in common”. Indeed, the word “common” means “belonging with or shared”. “Community” refers to a unified body of people sharing beliefs or physical location.

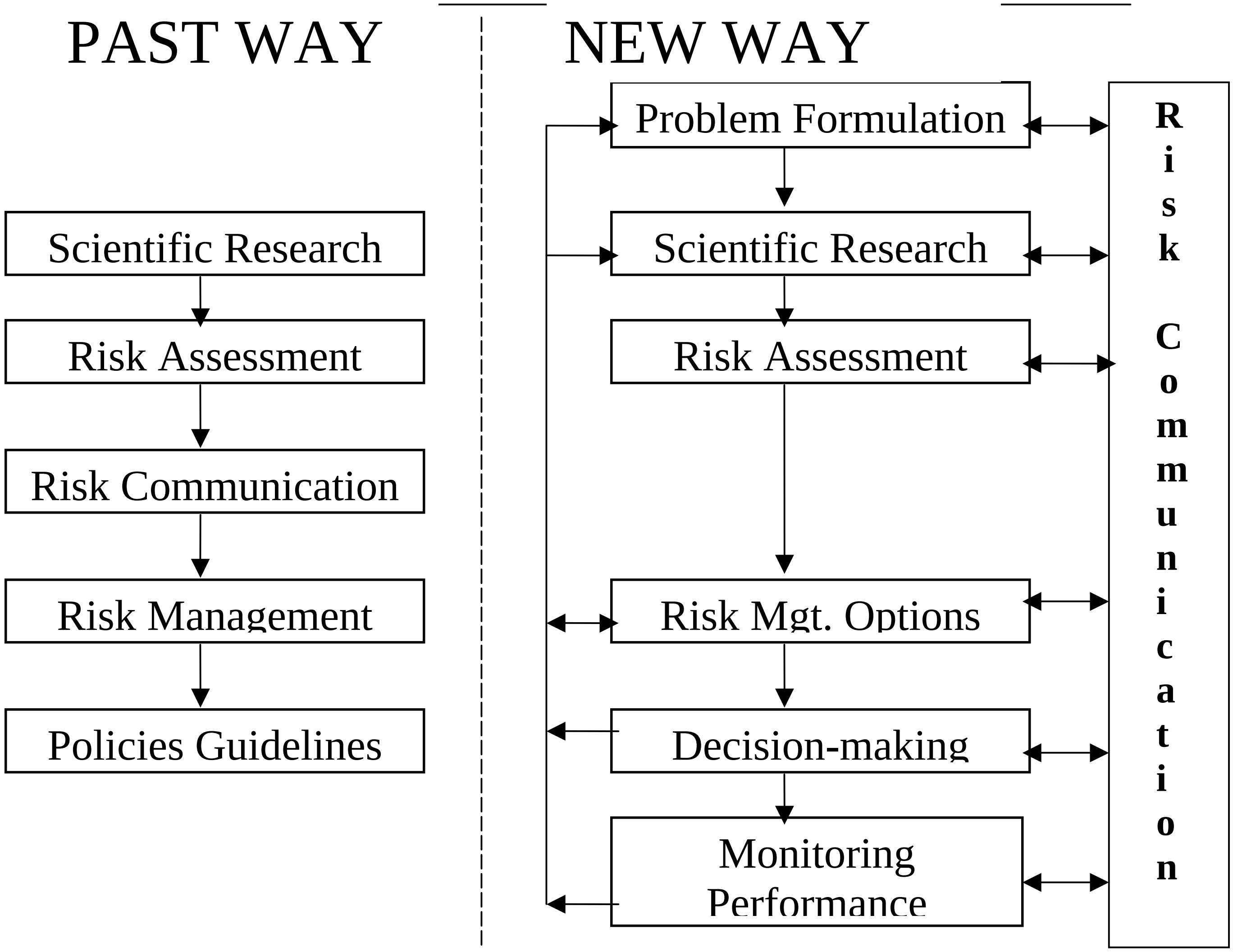
Humans have been around for roughly 7 million years. We share 98% of our genetic proteins with our primate relations, bonobos. But we have important distinctions in our genetic coding. Our skeletal and muscle structures allow us to stand upright and to use our arms and hands for purposes other than locomotion. Slight alterations in DNA over many million years changed our larynx, vocal cords, tongue, mouth shape and muscle structure which allow humans to utter an enormous variety of sounds. With changes to a small area of our brain, we gained the ability to assemble, remember and utter sounds in syntax. These latter changes occurred only about 40,000 years ago, a time that coincides, according to anthropological studies, with the beginning of human inventiveness. This is not surprising. Language is invention itself. We form sounds into syllables, syllables into words with meaning, words into phrases, phrases into sentences and sentences into a progression of thought. In their present complexities, spoken languages were developed about 5000 years ago. Written languages followed rapidly thereafter.

Communication, however, is difficult. An average person is exposed to 7000 bits of information each day, which is about one bit every seven seconds. If you are average, you will perceive under normal circumstances about 700 bits/day. You will acknowledge the perception of about 70/day, you will store 7/day in short term memory and you will be able to remember in the long term only 1 per day. That is a pretty dismal success rate. We can improve this in special settings, such as this conference, where attention is more focussed and the speakers are hopefully articulate. Recognizing this, each of us should, in everything we do,take steps to optimize the conditions for our communications.

In the workplace, as well as private life, the need for effective communication is increasing. The pace and amount of information is increasing. The complexity of technology is expanding rapidly and education, training, and the need for procedures and manuals is very high. Very few jobs are solitary. In workplace projects, the ratio of collective knowledge to individual knowledge is increasing. The key to a safe and productive workplace is communication. Careful energy must be expended to do it well. Nowhere is this more evident than in the communication of risks to health and the environment.

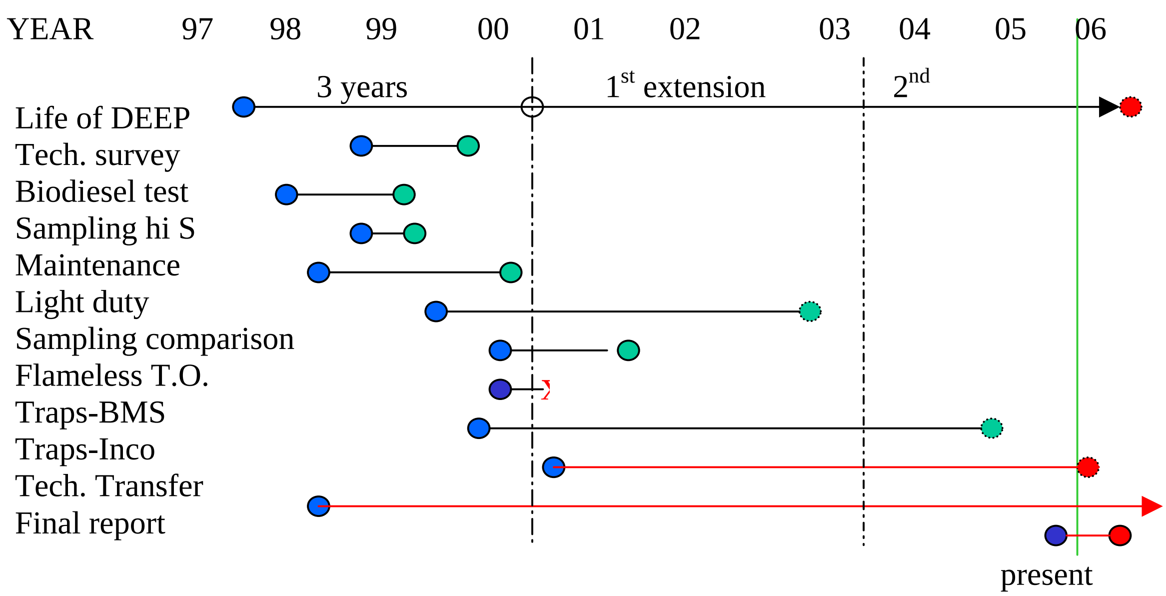
Risk communication is the exchange of information between stakeholders about the existence, nature, form, severity or acceptability of risks. In dealing with risks from industrial activity, who are the stakeholders? Anyone who thinks they are, including other businesses, labour, the media, individuals, associations, public health agencies, and local, provincial and federal governments. In the past, risk communication was viewed as one in a sequence of tasks, as shown on the left side below. This consisted of telling people what risk existed and how it was going to be managed.

The new framework, shown on the right side below, shows that risk communication has to take place throughout all other tasks. Each step of the risk management process must involve multi-pathways of dialogue among stakeholders.



The greatest advantage to doing risk management is its ability to organize and examine scientific and socio-economic information in an open forum of concerned parties. As we have seen for any effort to organize against chaos, the activity only succeeds by spending huge amounts of intellectual and emotional energy. I believe this is exactly what we've been doing in DEEP, which grew out of this conference some years ago. We've been at it for about 8 years. Why so long? It takes time to formulate the problem and to ask the right questions and to choose the scientific work that can best answer the questions. It takes energy for many stakeholders to reach consensus. But we have done this in DEEP and we have been rewarded with new knowledge and a better understanding of how we can collectively move forward with a reduction of miners' exposures to Diesel Particulate Matter.

As most of you know, DEEP was formed in 1997 as a research consortium aimed at evaluating technologies that could be used in rugged underground mining environments to reduce exposure to diesel particulate matter (DPM). All of the barriers to efficient and speedy decision-making were present in the early years of DEEP. But we stuck with it and developed trust in one another. And the end result is that we have done some very good work. As shown in the figure below, DEEP is coming to an end in the next few months. We have achieved important results and one of the ongoing goals of the stakeholders is to supply technology transfer.



We established a website early in DEEP and posted all project final reports on it. Also, short summary reports for all projects will be posted there, as well as the DEEP Final Report. Workshops have been an important component of the communication of DEEP results. An intensive maintenance workshop was held in 2002 by S. McGinn as part of the MDEC. J.Stachulak has convened workshops in Sudbury dealing with diesel particulate filter system selections in 2000 and results of field tests at Inco in July, 2004.

Four special regional workshops have been held on DEEP issues and projects during 2003-04: at Marathon, Ont. attended by 26 people; at Val d'Or, Que. with 38 people; Saskatoon with 32 people and Bathurst, New Brunswick, with 37 people.

DEEP has given presentations at conferences worldwide. We have been actively participating in every MDEC. We were at Mine Expo 2000 in Las Vegas, at the 6th Int'l Symp. On Ventilation for Contaminant Control in Helsinki in 2000, at the 4th Int'l Occ. Hygiene Assoc. Conf. In Cairns, Australia in 2000, at the 7th Int'l Mine Ventilation Congress in Cracow, Poland, in 2001, at the MSHA Conference in 2002 in Sudbury, at the NIOSH Diesel Workshop in Cincinnati in 2003, at the Society of Mining Engineering in Cincinnati in 2003, at the Caterpillar Engine Workshop in 2004 held in Peoria, Illinois, and at the 8th Mine Ventilation Congress in Brisbane in July of this year. This activity has allowed us to interact with colleagues doing similar research worldwide and enables us to bring the state-of-the-art science home to Canada as well as taking Canada's experience to others.

Another interesting thing was just communicated to me a few days ago by M. Grenier. It seems a man by the name of Robert Juuti, who works as a lone heavy equipment mechanic at a remote mining camp in Canada, found DEEP's website and was interested in more information about the use of the UGAS exhaust analysis system that Sean McGinn had so successfully applied during the DEEP maintenance project. Mr. Juuti contacted Charlie Graham at CAMIRO, DEEP's treasurer, and Charlie quickly contacted M. Grenier, who, in turn, got in touch with Sean McGinn. It turns out Mr. Juuti is going to purchase a UGAS and Sean is going to train him on how to use it. That is very successful technology transfer.

It is part of our essential nature to communicate, whether by sharing our genes to create a new human life or whether by sharing information for our common good. We find ourselves as self-conscious creatures in a universe bent on achieving chaos. While we are alive, we try to keep the chaos at bay. Being human means we have a desire to communicate. Let us spend our energy on this objective wisely. And let us be intent on

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engaging in true dialogues that will help deliver us to the final common goals we all share.

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