Knowledge Innovations: The Endless Adventure

by Anthony G. Oettinger[1]

Today, I shall draw on the resources of the Harvard Program on Information Resources Policy www.pirp.harvard.edu/home.html which I chair, to help us to celebrate our knowledge innovation (KI) heritage and consider its future.

Let me begin by showing you where we have been and where we are today. I have picked my examples to illustrate common and recurrent feelings of ecstasy about both promise and accomplishment in knowledge innovations. Curiously, these same examples illustrate common and recurrent feelings of agony – again, about both promise and accomplishment in knowledge innovations. I shall attempt to explain why this is so.

For designing our future I shall modestly limit myself to setting before you – in the hope you will find them useful or at least illuminating – some fundamentals that I believe have enabled and constrained the evolution of knowledge innovations. If my views are correct, these same fundamentals shall continue in the future, and they account for our common and recurrent feelings of both ecstasy and agony.

Celebrating Our Heritage: KI: Whence?

As a starting point, today I will choose the end of World War II. At that time modern digital information technologies began to take off. My title for this talk, *KI: The Endless Adventure*, plays on the title of a report written right after World War II by one of the leaders of the research and development effort that was so crucial in winning the war through the use of new technologies like the atom bomb, radar and computers. The report was called *Science, the Endless Frontier*.

At about the same time its author, Vannevar Bush, then director of the Office of Scientific Research and Development, also wrote an article for *The Atlantic Monthly* magazine. That article set forth a vision of knowledge innovations that is fresh and to the point to this very day, over half a

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century later. These two texts that Bush published in 1945 are the milestones I have chosen to begin my account of where we have been. The sexy title, "*As We May Think*," (The Atlantic Monthly, July 1945, 176 (1), 101-108; www.theatlantic.com/unbound/flashbks/computer/bushf.htm was an attention catcher then and still is today.

Imagining the clutter and clitter-clatter of his typewriter is but to underscore how visionary Bush truly was, writing at a time when the typewriter was the measure of information-processing speed, not the nanosecond or the femtosecond. I would paraphrase Bush's central propositions in the following way:

- Amassed knowledge is outrunning our ability to use it.
- Information Technology (IT) can fix this.
- Let's call that IT fix "Memex."

Let us turn to how Vannevar Bush himself expanded in his own words on each of these three points.

Amassed knowledge is outrunning our ability to use it: "The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships." This sounds very modern, except that we might not evoke sailing ships. We might instead evoke legacy mainframes from the days before the Internet.

IT can fix this: "Such machines will have enormous appetites. . . will take instructions and data from a whole roomful of girls armed with simple keyboard punches and will deliver sheets of computed results every few minutes. There will always be plenty of things to compute in the detailed affairs of millions of people doing complicated things." Note Vannevar Bush's casual reference to a roomful of girls, so politically incorrect today, and to their keyboard punches. Of course keyboard-data-entry boiler rooms are quite common around the globe today, although almost instantaneous display of a customer record has replaced the printing of "sheets of computed results every few minutes."

Note especially how, in the second sentence, Bush has shifted the context from "the summation of human experience" to "the detailed affairs of millions of people." In contemporary terms he has shifted his ground from the most pie-in-the-sky wish list of knowledge innovations to the most down-to-earth bread-and-butter of transaction processing.

The subtle, perhaps unconscious, shifting of ground from knowledge enhancement to transaction processing makes a world of difference as regards the likelihood of experiencing the ecstasy of accomplishment versus the agony of failure. Why this bait-and-switch distinction is so fundamental is the central point that I aim to develop in the remainder of this talk.

Let's call the IT fix "Memex": "the basic idea. . . is a provision whereby any item may be caused at will to select immediately and automatically another. This is the essential feature of the Memex. The process of tying two items together is the most important thing." "So he sets a reproducer in action, photographs the whole trail out, and passes it to his friend." Vannevar Bush clearly had the contemporary marketeer's flair for the sexy name.

The effect of this sloganeering is what Bush's contemporary, the British philosopher K.J.W. Craik, called "false hypostatization." (The nature of explanation. Cambridge, England: University Press, 1952.) In plain English, this means giving the false impression that because there is a name, there must also be something that the name names. Think of Pegasus, the winged horse! False hypostatization leads to that ecstasy of anticipation of early achievement (Nobel Prize, IPO, whatever your favorite fantasy) that energizes both scientific inquiries and entrepreneurial venture.

What Memex names continues to be the Holy Grail of what I call the Artificial Intelligentsia. But I remind you that here, today, in the year 2000, it is I, not a machine, who remembered "As We May Think" as a seminal reading from my youth. I recovered it from The Atlantic Monthly's online archive with a well aimed intellectual rifle shot, not a vague Internet search. Think of your favorite browser and then imagine doing that trail with microfilm, the hot new technology of Bush's day. But what a vision! What an inspiration! What ecstasy!

Celebrating Our Heritage: Where Are We?

How is Vannevar Bush's vision faring 50 years later? Is the inspiration alive and well? Let's try searching "information technology" on Yahoo:"5223 sites in 127 categories. . ." Those search results are what you get today on the Web! Think of setting Vannevar Bush's "reproducer in action, photograph[ing] the whole trail out, and pass[ing] it to [your] friend." The good news is that technology can do it today, when it couldn't in his day. The bad news is the same agony: excessively high recall, excessively low precision.

But please note that hope also springs eternal, along with despair! Bush's ecstasy, too, is alive and well, albeit expressed in the contemporary

corporate jargon! “What if you lived in a world where computers could make sense of the ever increasing volumes of Web pages, emails, documents... ”Indeed, right here, today, within the hour, in the session that follows this talk, we shall have an ecstatic claim: ”Effective Cross-Language Information Retrieval (CLIR) systems save Internet users from [Babel]. . .”, tempered by an agonized disclaimer, “Panelists will explore the use of new technologies to overcome problems inherent in CLIR.”

Designing the Future: Agony and Ecstasy Forever?

What’s going on here? What can we learn from the past and from the present that might shed light on how to place our bets on the future? So far we have observed recurring ecstasy over amazing progress in IT as applied to transaction processing and the like and recurring agony over losing ground in extracting knowledge from data. I shall now attempt to explain why this combination of ecstasy and agony keeps recurring and why I think we will cycle through ecstasy and agony forever. I propose two fundamental, interlinked reasons:

· **IT sometimes helps.** We’re ecstatic when IT helps us, but we agonize when it fails and, in our agony, we turn once again to ourselves, to people. But...

. People’s M.O.s (modus operandi) are eclectic and – sometimes – mysteriously effective.

Let’s look at the details of those two propositions.

Information Technology. Let us have a closer look at when IT can help. As shown in Figure 1 information is only one of three basic resources on which all of us depend, the other two being energy and materials:

- Without materials, there is nothing.
- Without energy, nothing happens.
- Without information, nothing makes sense.

IT has gotten amazingly smaller, faster, cheaper, better in the last few decades – a trend that promises to continue into the foreseeable future, but which is not nearly so much in prospect for energy and materials.

In such a context, information is important, but it is most often only the means to other ends. You can’t eat information, you can’t wear it and you can’t live in it. For instance, ecstasy about the marvelous information flows involved in e-commerce turns to agony if the goods can’t be

manufactured and delivered to you. That is why United Parcel Service stock rose along with the dot-com stocks.

Figure 1 also displays three distinct aspects of information: substance, format and process. The substance of information is its meaning, its significance, what we value it for. The format of information is its shape, its embodiment, like ink on paper or sound in the air or pixels on a flat-panel display. Information processes transport, combine or transform formats.

IT has given us an abundance of new formats that are much smaller, faster, cheaper and better than anything that Bush foresaw. IT now enables us to process these formats with speed that would boggle his mind.

But there remains a fundamental limitation on these processes that 50 years of efforts by our colleagues in the artificial intelligentsia have barely begun to alleviate. Creative processing of substance to turn raw data into useful knowledge remains a monopoly of our flesh and blood minds. In 2000, as in 1945, Bush's "As We May Think" remains a tantalizing speculation, not a fait accompli. When it comes to thinking, IT still can't hack it. And, as we shall see, when it comes to thinking and acting collectively, we don't shine so brightly either.

In Figure 2, The Information Business Map, we apply the aspects of information in Figure 1 to analyze the conditions under which IT is most or least likely to help us. The vertical scale of the map runs from products to services as the buyer's ongoing dependence on the seller increases. The horizontal scale runs from pure forms, namely formats and processes devoid of substance, to pure substance, namely substance whose embodiment is of quite secondary interest to the buyer.

As the examples located on the chart illustrate, goods toward the left of the map are either devoid of substance, such as blank paper, or leave substance unaffected by whatever processes are applied to the formats that embody the substance. Such examples include the transport of a sealed envelope or the faithful transmission of an e-mail message. In these instances improvements in IT lead, in the short run, to performance improvements that match results to expectations and smooth out the peaks of ecstasy and the valleys of agony.

At the other extreme, in the upper right hand corner of the map, where the examples are the services of people deciding, people advising and people authoring, the activities are all about substance. The peaks of ecstasy and the valleys of agony are most pronounced here where the substance of information matters and, especially, where the substance of information is undergoing change. Here IT helps the least.

So the headline from a recent article in the New York Times should not surprise us: "*The Search Engine as Cyborg: As the Web sprawls out of control, search engines are overheating and programmers are trying something new: human beings."* (June 29, 2000, p. E-1) This is the contemporary reaction to our contemporary agony: The headline is good news for some of you: thinking human indexers and thoughtful human editors are in for a renaissance, applying new means to traditional ends.

What is the bad news? The bad news is that people are all over the lot. Sometimes we are mysteriously effective. Sometimes we are also ineffective in mysterious ways that limit the scope of useful exploitation of IT for knowledge innovation, even when people are doing the thinking.

Hence the recurrent ecstasy over what we hope to do with new IT and the recurrent agony of re-discovering not only that IT can't hack it without people, but that people aren't the answer either.

People To help clarify where people are fundamentally limited, allow me first to introduce you to some detail about people's M.O.s and, second, to introduce you to the UAPS, the Universe of All Possible Substance.

In the real world, people use all of the processes shown in Table 1. The table focuses on processes we use to guide our business decisions. IT can help mightily with some of these processes, mainly the formal ones, but not at all with others among them, especially the informal ones.

	Inside Sources	**Outside Sources**	**Personal Knowledge**
Formal Processes	**MIS; Scanning Special studies**	**Web search; Traditional media; Trade associations; Consultants**	**Training** **Education**
Informal Processes	**At the water cooler: "What do you think, Joe"?**	**Web browse** **Golf course** **Cocktail parties**	**Experience**

Let me try to sharpen this insight further by calling to your attention a process that is a prerequisite for any meaningful application of the processes listed in this chart. It is the process of aligning our universes of discourse so

that meaningful conveyance of substance can take place. What do I mean? To explain it, I invite you to consider the UAPS, the Universe of All Possible Substance. The UAPS encompasses all the data, all the information, all the knowledge, all the wisdom that ever was, that is now and that ever will be. The UAPS is therefore boundless, and only an eternal and omniscient being could fathom it all.

Which leads me toward what is possible for us mere mortals and to what there is to align.

If the UAPS is a continuum, then you and I have only a limited window on it (Figure 3) laboriously gained through all the formal and informal processes I listed in Table 1. This window is my universe of discourse. It is surrounded by the limitless expanse of the unk-unks, the unknown unknowns, the things which each of us doesn't even know we don't know. The unk-unks are literally and figuratively the darkest part of this picture. Even our open window is usually beclouded by what the military strategist Von Clausewitz referred to as "the fog of war." The little dots denote the fog beclouding our window on the UAPS.

So, what is there to align? It is not only that our windows on the UAPS are narrow slits in the infinite expanse of unk-unks, they are also usually misaligned. Some communication may be possible between the people depicted in the top two rows of Figure 4, but neither of them has anything substantive in common with the person depicted in the third row. Their universes of discourse do not overlap.

This misalignment is not necessarily a matter of not speaking the same language. More fundamentally, it is a matter of seeing different aspects of the world through different lenses. For communication and collaboration to exist, in other words for a coherent social order to exist among this group of three, their windows on the UAPS must at least overlap.

Aligning the UAPSs What does it take to get our universes of discourse, our windows (or UAPSs for short) well aligned? Two sets of concepts will help us understand. The first set of concepts breaks substance down into two aspects: cow and bull.

- Pure Cow is data without any frame of context or frame of reference.

- Pure Bull is context or frame of reference, without any data.

Cow and Bull here are technical terms, no pejorative connotations intended. Knowledge is born of the union of cow and bull, whereby data become meaningful relative to a specific context or a frame of reference. The

second set of concepts breaks circumstance down into two aspects, namely stasis and change. Here are my rough-and-ready definitions:

· Stasis is the way it was, or seemed to be, in the good old days when tomorrow was like yesterday.

· Change is the way it is now, ever since the Internet hit the fan. . . and promises to be for way ahead.

If we combine substance and circumstance (Table 2) we now have in hand enough conceptual armament for a closer look at why the peaks of ecstasy and the valleys of agony are most pronounced when the substance of information is both relevant and undergoing change. And why, under these conditions, IT performs the worst and our windows on the UAPS need the most alignment.

	Cow	Bull
Stasis	Steady-state Cow	Steady-state Bull
Change	Transient Cow	Transient Bull

Consider the combination of Transient Cow and Transient Bull. Here, there is no stable context or frame of reference in which to interpret data, which itself is changing. Our windows on the UAPS are totally fogged over. Under these circumstances, IT produces GIGO (garbage in and garbage out) at its worst: a deluge of changing data that is uninterpretable in a shifting context. Economic productivity data from 1990 forward is a prime example.

People cope as best they can, the sensible and aware ones shifting their reliance from the formal processes to the informal in Table 1. Venture capitalists place bets, and those who are both smart and lucky survive. Once the winner is known and when and if stability returns, everyone's window on the UAPS gets aligned with the winner's. With 20/20 hindsight, the winner then looks prescient. There is ecstasy for selected entrepreneurs at the time when bets are placed, agony for the losers when the startup fails, as most do.

On the other hand, Steady-state Cow (data) in conjunction with Transient Bull (context) gives the illusion of knowledge, an illusion born of

the mismatch of cow and bull. Data is meaningless in a shifting context. Consider the monitor information at any major airport in foul weather.

In the third case, Steady-state Cow coupled with Steady-state Bull gives us accepted and stable knowledge. Newtonian mechanics for the solar system is perhaps the best example. We confidently rely on its theory and its data to send people to the moon, to lob missiles across oceans and to design thrill rides for amusement parks.

And finally, of course, Transient Cow and Steady-state Bull: knowledge born of the union of cow and bull. Change is intelligible in a reliable context such as stock prices and indices in a stable economy.

Lest these four baby examples mislead you into thinking that I'm playing childish games, let me conclude with a few glimpses of a thorough study of a real life situation. In this instance IT sometimes helped and sometimes failed, and the misalignment of UAPSs, owing to mind-boggling mismatches of cow and bull, led to tragedy of a not uncommon kind.

I quote from a forthcoming review by Karl E. Weick, a professor at the University of Michigan School of Business Administration, of Scott A. Snook's Friendly Fire: The Accidental Shootdown of U.S. Blackhawks over Northern Iraq (Princeton University Press, 2000) to appear in Administrative Science Quarterly: *"Friendly fire"* is a military term that refers to casualties unintentionally inflicted on one's own forces. . . . Twenty six. . . people died by friendly fire during peace-keeping operations after the Gulf war, when two US Air Force F-15 fighters shot down two US Army helicopters as a crew of 19 AWACS (Airborne Warning and Control System) air traffic controllers, in charge of those 4 aircraft, looked on. This shootdown, which occurred on April 14, 1994, is the subject of this remarkable book by Scott Snook.

The heart of the matter is expressed in one of many vignettes in the book that focus on misaligned UAPSs and on mismatched cow and bull: [Snook] shows that meaning rather than decision making is at the heart of the shootdown. There is a fascinating glimpse of just how complicated organizational behavior can be. The task force commander of this Iraqi... operation, General B.G. Pilkington, is the exemplary leader we all talk about. But his hands-on experience has blind spots. He piloted F-16 aircraft, which fly both at high and low altitudes and whose pilots are briefed about low flying aircraft (p. 175). Pilkington assumed that all pilots, including F-15 pilots, were similarly briefed, which was not true. Because he had been so close to the action, Pilkington assumed if there was a lack of integration among the services he would know about it. Since he didn't know about any lack of integration, then it didn't exist. . . .

Organizations that face trying conditions with catastrophic potential have now become the rule rather than the exception. Scott Snook has raised for all of us the fascinating question, what is the equivalent of friendly fire in non-military settings? When do we mistake friendly helicopters for unfriendly enemy? Do we have leaders whose knowledge is equivalent to “pigs looking at watches”? Do we innovate and assume that others with whom we mesh are not and are toeing the line?

To reemphasize what Weick sees as one of Snook’s key findings: “[Snook] shows that meaning rather than decision making is at the heart of the shootdown.” Weick says “meaning” where I would say “substance,” but the point is the same.

To quote further from Weick’s review, “The on-board commander, the highest ranking person on the aircraft testified that. . . he had ‘no idea what those radar blips mean.’ (‘I’m like a pig looking at a watch.’)” Another barnyard figure of speech! I would say, “I’m looking at pure cow without bull to interpret it.” (Testimony quoted from Fire, p. 127.). In short, Weick’s generalizations from Snook’s case study are “Do we have leaders whose knowledge is equivalent to ‘pigs looking at watches’? Do we innovate and assume that others with whom we mesh are toeing the line?”

Living together, learning together, doing together are the traditional and still the most effective known means for achieving a modicum of overlap of the disparate windows on the UAPS of new hires in the corporation, of raw recruits in the military or of entering freshmen in academe. This is what team building is all about. It is also where IT still can contribute the least.

This fundamental truth about KI accounts for why so often the initial ecstasy over new IT turns into agony when the realization sets in that the new IT can do little to help to sidestep the cost of education, indoctrination or training. Hence it can save little in money or time to be paid for aligning people’s windows on the UAPS, windows that are usually shifted and befogged by the very process of innovation

Weick’s conclusion and my recommendation to you: “The questions, both in practice and in theory, that flow out of this book seem to be endless. I can’t wait to teach this book to Ph.D.s as well as executives. I can’t imagine anyone who wouldn’t benefit from grappling with it.” For more specific or greater depth on my talk today, please see the publications of the Program on Information Resources Policy, Harvard University, which are accessible and downloadable at www.pirp.harvard.edu/pubs/home/html .

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A note on figures and tables: Figures 1-4 and Table 1 were adapted from articles by Mr. Oettinger and co-authors that appeared in Compaine, B.M. & Read, W.H. (Eds.) (1999). The information resources policy handbook: Research for the information age. Cambridge MA: MIT Press. Table 1 was adapted from an article “Managing information: Back to basics” by B.M. Compaine and J.F. McLaughlin in that same publication (p. 369).