GLOBAL TECHNOLOGY ASSESSMENT:
Managing the Moral Hazard of Disruptive Technologies

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Of the many interpreters of technology, Marshall McLuhan is one of the most notable. He used the example of communication technologies as his archetypal choice to illustrate the social nature of innovations, particularly in his last book, The Laws of Media.\(^1\) That book summarizes the many case studies and conclusions that he had accumulated over the years.

Without explicitly making the claim, McLuhan provides the philosophical frame for Technology Assessment in this book. Preceding “assessments” and “evaluations,” it is essential to ground such efforts on accurate observations of the way these phenomena actually operate. This requires socio-cultural diagnosis premised on a level of analytical sophistication rarely achieved.

McLuhan’s “four laws of media” are a solid beginning for this philosophical framing. He identifies “four effects” that are exhibited by virtually all newly introduced innovations. To complete this task however, “four second-order accompanying impacts” must also be specified, one corresponding to each of the “four effects.” The “four impacts” show the kinds of results that the “four effects” produce (see below).

<table>
<thead>
<tr>
<th>Effects</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieval: no innovation is entirely new – each borrows some elements from previous practices.</td>
<td>Novelty: all innovations have some original aspects (design parameters and/or use patterns).</td>
</tr>
<tr>
<td>Enhancement: improves the design parameters and/or use patterns in terms of better functionality.</td>
<td>Disruption: undermines prevailing social arrangements and disorients participants.(^2)</td>
</tr>
<tr>
<td>Obsolescence: renders previously designed infrastructure comparatively non-competitive for efficiency/efficacy.</td>
<td>Replacement: requires scrapping of old infrastructure to achieve newer levels of efficacy and/or efficiency.</td>
</tr>
<tr>
<td>Reversal: once absorption has reached saturation, over-use undermines previous gains.</td>
<td>Extension: technologies manifests themselves increasingly throughout social space.</td>
</tr>
</tbody>
</table>

Given the effects and impacts that innovations will display, how much latitude exists to design and deploy technologies so that benefits will be maximized, detriments will be minimized, and adjustments in use patterns can accommodate a range of consumer and user preferences? This question is the premise upon which the practice of Technology Assessment is built. Once stated so explicitly and globally, the potential for the task becomes much more systematic and comprehensive.

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\(^1\) Marshall & Eric McLuhan, THE LAWS OF MEDIA, University of Toronto Press, Toronto, 1992

Introduction

THE CASE FOR GLOBAL TECHNOLOGY ASSESSMENT

Most people naively assume that most technologies are mostly beneficial. What is this assumption based upon? Proponents of technology have contrived to make the case that technologies are “applied science,” and hence technology is neutral just like science. Science however, is not neutral — contrary to Max Weber’s hypothesis of “value-free” science, the practice of science actually implicitly incorporates many of the values and goals of its social context. For instance, the usefulness of accurate observation depends for its effects on the premise of “honest reporting,” and “honesty” is a value. Every procedure of science has such a hidden premise. Technology therefore applies values as well as facts and principles.

One of the important premises of technology is that the tools and techniques so contrived will be “beneficial” (advantageous or helpful\(^1\)). But one person’s advantage may be another person’s disadvantage. Every previous civilization has collapsed because of the use of unsustainable economic and ecological activities. Our commercial civilization is now repeating this process. Technology simply drives the process faster, and spreads the problem wider.

How are the promoters of technology able to rationalize this process? They focus on short-term goals and immediate gratification. The “lifestyle of products” is fun, exciting, carefree, and empowering — what most have lost sight of is that the long-term prospects are disadvantageous and detrimental. To use prevailing metaphors, we are “living in a fool’s paradise,” “engaged in a suicide mission,” and “riding on a death-train!”

The “direct approach” is to assess technology is terms of its total compliment of advantages, disadvantages, benefits and detriments. This must of necessity be a learning process, because we still do not possess fully mature techniques of foresight, assessment and evaluation. However, enough has been learned in the 20th century, and sufficient historical case-studies been recorded that we can begin the process of assessing every existing and prospective technology on the basis of its merits rather than on the good opinion of its proponents. The longer we wait to begin this process, the more and more difficult the problems of rectification will be. If we do not adopt this process, our future is doomed. We are over-mining and over-harvesting our resources, and polluting and degrading our environment. As the world’s population grows bigger, its wealth is increasingly mal-distributed. It is as if humanity has a collective version of Freud’s “death-wish!” Another aspect of modernity is interfering with our capacity for action — the “let somebody else do it” syndrome. Consumerism has been encouraging us to demand our rights but shirk our responsibilities. Will we finally come to our senses and start exercising some good sense? As this book demonstrates, I am dedicated to the proposition that a better future is both desirable and possible. Will you join me?!

\(^1\) Definition of beneficial from Dictionary.com
Any proposed product design, whether in the “goods” or the “services” category, will likely emerge out of a research and development process (R&D), wherein the prospective innovation has been researched, designed, tested, re-researched, re-designed, retested, etc. through a number of iterations. Depending on what is being “developed,” there may be a variety of dimensions that have to function together AND satisfy ergonomic (user-friendly) and social (performance and style) considerations.

Before design begins however, there is “pre-design,” the stage preceding when designing actually commences. For consumers, this will likely occur because something that they perceive as desirable is either not being done, or could be done better. If there are persistent traffic jams, perhaps the road could be widened, or the traffic re-routed, or more public transit could be used. For producers, they could be looking to increase market share, move into a new market, or diversify their product offerings. If the sale of family-sized cars is stalled or declining, perhaps a flashier model would sell better, or compacts could be pushed, or a more robust market for pick-up trucks could be developed.

Once the desire exists to get a new or different or better “product,” this desire must be translated into design specifications if something is going to actually be produced. One contributor to these specifications, is “need assessment” – prospective consumers and users are interviewed concerning their needs and wants regarding the kind of product being contemplated. Repeated experience has shown that attempts to “guess” what customers need, is rarely as reliable as actually asking them, although many producers ignore this. On whatever basis however, perceived needs are eventually translated into specifications, and then into prototypes.

Usually these prototypes are then “market-tested.” Select consumers are given the opportunity to use the new product and report back on their experiences with it. These reports are the basis for “re-design,” because not all of the hopes and expectations of designers and producers are realized. Perhaps the prototype does not provide all the functionality the consumer wants; perhaps it is too complicated for user-friendly control; perhaps the suggested price is too high, etc. Based on initial user feedback, the prototype is re-designed and tested again, until an acceptable product emerges.
Why do innovations occur? Innovations are produced by people, whether individually, in groups, or in organizations. So what motivates them? Although there is often a complexion of motivations, the discussions usually “boil down” to just two concerns: needs, and/or wants.

Some people proclaim a profound difference between needs and wants. According to this view, when a person has a need there is a necessity to fulfill it for that person’s wellbeing. By implication, when a person’s need is not fulfilled their wellbeing is diminished. In contrast to this, a want is something wished, desired or striven for. From this perspective, when a want is not fulfilled it is the person’s vanity, preference or pride that is thwarted.

This approach to “needs” and “wants” dichotomizes them – places them on the opposite ends of a spectrum. However, others see needs and wants as simply two aspects of the same thing. “Basically, a need is concerned with something that is wanted.”1 Given these two approaches, what is apparent is that both “needs” and “wants” are part of a larger “family of concepts.” What this means is that needs and wants both share some similarities, AND also display some differences.

When the terms “needs” and “wants” are used, we will acknowledge some overlap in meaning, and try to be clear as to whether similarities or differences are being emphasized.

People who produce innovations want to make a return on their investment in developing and deploying the innovation. They may believe as well that they are fulfilling some consumer needs. Consumers who use innovations may do so for personal and/or social reasons. They may also believe they are meeting certain of their needs. In the cases of either producers or consumers, the important assessment is NOT motivation, but rather the impact that using innovations will have, on themselves, on other people, on organizations and on the environment.

Over the previous 400 years, innovations have increased standards of living, sizes of populations, patterns of settlement, lengths of lifespan, channels of communication, and qualities of life, to an unprecedented extent. Furthermore, the innovations forecast for the foreseeable future promise even greater transformations. In the process of all these changes though, a variety of harmful impacts have also been caused by these innovations, and the prospects are that unless such impacts are controlled, they could offset most of the benefits that people are seeking. Marshall McLuhan called this irony “The Reversal Effect,” and it could wreak havoc with both society and environment if we do not take the proper precautions. We have to assess innovations so as to increase their benefits and decrease their detriments during both the design process and the deployment process. Humanity has now acquired enough experience with, and knowledge of technologies, that we can mandate better designs and effective retrofits so that we reduce the risks of damage to each other and to nature.

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1 K. Holt, H. Geschka & G. Peterlongo, NEED ASSESSMENT, John Wiley & Sons, Chichester, 1984
A closer look at research on “the need for innovations” is revealing.\(^2\) When the primary motivation for an innovation is “consumer wants,” the result is called “need pull” technology. When the primary motivation for an innovation is “producer wants,” the result is called “technology push.” A study of eleven successful innovations, eleven failed innovations, and ten projects in process, gave the following results: “…8 of 11 of successful innovations were initiated by the ‘need pull,’ whereas nine of 11 failures were originated by the ‘technology push,’ i.e., ideas originating from the engineering staff.” Further research concluded, “It appears that most new products are the result of chance occurrences or intuitive decisions made in an improvised manner unrelated to any overall strategy.”\(^3\)

In an idealized model of “need assessment,” consumer wants and producer wants are blended to produce the innovation. BUT, to accomplish this, the proper research tools must be used for:

1. Need identification – what “problem” is the innovation supposed to solve?
2. Need evaluation – does the proposed innovation properly responds to “the problem?”
3. Need clarification – is the innovation a feasible solution, given the problem context?
4. Need specification – how exactly will the innovation address “the problem?”
5. Need updating – if the perception of need changes, does the innovation change as well?

These rules can be summarized this way: is the problem worthwhile tackling, AND is the solution worthwhile deploying? Do the wants from a producer complement the wants from consumers? If there is an alignment of such wants, does the solution proposed adequately address the substance of the problem? OR, are the consumer wants largely a matter of “wishful thinking?” OR, are the producer wants largely a matter of “exploiting naiveté?”

Based on a balance between the wants of consumers and the wants of producers, what are the questions that should guide a Needs Analysis in particular, and a Technology Assessment in general?

(a) Are the objectives worthwhile?
(b) Are the technologies efficacious?
(c) What are the beneficial effects?
(d) How can we enable and enhance the benefits?
(e) What are the detrimental effects?
(f) How can we eliminate or minimize the detriments?

These are important questions because of the consequences of the answers. It is no longer safe to let technological development occur haphazardly, intuitively, and without an overall strategy. We have experienced too many toxic products, system overloads and industrial accidents because of a lack of due diligence. We should do better, to reduce harm we have to do better, and with Technology Assessment we can do better!

\(^2\) Holt, Geschka & Peterlongo

\(^3\) Holt, Geschka & Peterlongo
NEED ASSESSMENT

Need Assessment should PRECEDE design, NOT occur during or after design! More often than not however, innovation producers are pre-occupied with gaining “mind-share” and then “market-share,” rather than providing public accountability. Part of “the problem” is that the rest of us then have to live with the results and consequences of this lackadaisical attitude. Would any of the early customers for automobiles have foreseen the development of paved highways, suburbs, shopping malls, and the automobile sales and services industry? Did the early airplane makers anticipate aerial warfare, or international tourism? Not likely, but both have now changed the world, for better AND for worse!

The concept of Life-Long-Learning is now very popular in both education and geriatrics. I like to think that the inspiration for L-L-L comes from the comment by George Bernard Shaw, to the effect that the problem with many people was that they didn’t live long enough, to get smart enough, to be able to develop productive solutions. Hopefully, what many of us lack individually, we can gain socially. I will argue, not surprisingly, that one crucial form of that Life-Long-Learning should be acquired through Technology Assessment.

The place to start a Technology Assessment is with a Need Assessment for any proposed technology. Technologies should NOT be given the “benefit of the doubt” – they do NOT have any rights to be “taken at face value.” In all likelihood any innovation will have a price tag, cause considerable disruption, and entail detriments as well as benefits. Therefore, those making the proposal have an obligation to present a prototype of their product, describe the problem it is supposed to address, demonstrate the solution it is presumed to offer, discuss likely detriments and how to deal with them, and invite suggestions for how to enhance the benefits and minimize the detriments. ANYONE who resists this process, becomes an automatic suspect for the attitude of “the consequences be damned” regarding their proposal!

So, what does a Needs Assessment consist of? First it is necessary to define the problem; who has the problem; what does the problem amount to; what is the context of the problem (who else, and what else do the problem and a solution involve)? Secondly, what is the proposed solution; is it technically feasible; is it socially acceptable; is it economically viable? Thirdly, what are the implications and consequences of the proposed solution; who does it benefit; who will suffer detriments from the proposed solution; will the solution likely create spill-overs outside of the problem area it is responding to, and if so, what type and how much? Fourthly, was provisions will be made to cope with whatever detriments emerge from the uses of this technology, either those that arrive sooner or those that occur later; commitment that the producers will agree to cover the costs of retrofitting or amelioration. No one with any good sense would accept a proposed new technology without these kinds of assurances!
As we all know however, that good sense is widely lacking in today’s world. Innovation producers are usually more concerned with the benefits they hope to receive rather than with any larger considerations. Innovation consumers are usually more concerned with the prestige and convenience of using “the new thing” rather than contemplating the consequences of their actions.

The “PROBLEM’ now however, is that some of the technologies currently being developed are on the verge of producing unprecedented effects on humanity and the environment. Four technologies in particular (info, bio, cogno, and nano), are developing in complementary fashion, so that each will enhance the others as well as produce its own effects.

The “purpose” for a thorough Needs Assessment is to provide information the innovation producers can take out of the process and return to their work environment where they can revise and/or refine their initial proposal. The answers to the Need Assessment questions will indicate a number of dimensions along which their proposal can be improved. They will also be aware that henceforth, any further action on the proposal will be tracked. If any of the detriments forecast do materialize, the producers will be held accountable, AND liable for the costs of retrofitting and/or ameliorating. No more free rides on the public’s good will – and no more externalizing detriments by disclaiming responsibility and leaving society to clean up the mess! If producers can profit from the benefits they provide, they can also pay for the detriments their products cause. That is the principle of reciprocity – if you impose costs on others, you should have costs imposed on you. It is the basis of social sustainability.

Are there any common themes in either Need Assessment methodologies or findings? Specific findings will, of course, depend on the particulars of each case, but there are some generalities which transcend this variability. First is the requirement to acknowledge and distinguish between (i) existing needs, and (ii) future needs.1 The major challenge of existing needs is to recognize the discrepancy between the existing situation, and what is wanted. As for future needs, because they do not exist in the present, but will materialize in the future, there is no substantial evidence of them in the meantime.

The other significant finding is the difference between emotional needs and rational needs. Emotional needs usually concern such esthetic characteristics as style, color, size, shape, etc. Rational needs are those that are concerned with function and use. “Ordinary customers are considered by many to be more influenced by emotions in their buying behavior than institutional users.”2 However, when institutional purchasers are given the discretion, they too may favor their personal preferences as well as rational needs when buying products.

1 Holt, Geschka & Peterlongo
2 Holt, Geschka & Peterlongo
METHODS FOR NEED ASSESSMENT

There are many “discovery methods” that can be used to ascertain the required facts and appraisals. Whichever ones seem appropriate to the situation, should be used. The substantive concerns are outlined below – any additional topics or techniques that a particular situation may require should be added to this list.

1. Compile a history of the producer’s R&D capabilities, manufacturing experience, and community outreach practices (public consultations, marketing approaches, feedback procedures, handling of criticisms).

Producers that have a history of R&D competence, are also likely to be willing and able to handle any alterations in design that Needs Assessment indicates are required to make an innovation safer and/or more user-friendly. Manufacturing experience indicates that any changes in design after deployment can be introduced into the production process in a proficient manner.

The presence of community outreach practices shows that a producer already has taken the time and effort to establish a working relationship with consumers, and so is more amenable to further community suggestions. If this type of relationship is lacking, a good show of faith would be the willingness to create such a relationship during a Needs Analysis. As to the specifics of outreach:

(a) Engaging in public consultations gives consumers the opportunity to speak for themselves rather than be represented, or misrepresented by others;
(b) The tenor of marketing approaches demonstrates whether producer advertising is responsive or manipulative;
(c) The way producers handle consumer feedback is an indicator of how “seriously” producers regard consumer concerns;
(d) One of the recent books on criticism by a consultant was titled “How Not to Take It Personally” – producers could read this one with great benefit!

2. Survey users of the type of innovation being proposed, regarding their current needs, present concerns, their future product preferences, and their responses to this particular proposed product.

The “current needs” of consumers, are often presumed or guessed by producers. Arguably this is why the Edsel Ford failed so miserably. Many producers just DO NOT WANT to ASK (God forbid!) what consumers actually think, or feel, about their latest offerings. And they have the most elaborate excuses for this attitude.
Asking consumers about their “future product preferences” is even more questionable than inquiring about their current ones, according to many marketing gurus. Why? Because, “change is inevitable” and “almost always for the better.” Rubbish! Here is another read: “Calling a Halt to Mindless Change.”

So, what DO consumers really think about the proposed product changes? The views are mixed. Hurray for the benefits. Boo for the detriments. But usually these views will be ignored UNLESS they can be used for marketing advantage. The role of advertising is to convince consumers to get on the bandwagon!

3. Consult Experts and Interest Groups regarding their responses to the proposed innovation, their estimates of the likely results of use, their forecasts of benefits and detriments, and their proposals for how to respond to the new innovation.

Professional Scientists, Engineers and Economists who are NOT employees or associates of producers, will usually have a considerably different view of prospective innovations that those who are “in cahoots” with producers. In all likelihood they will be:

(i) Skeptical of the producers rationale for the innovation –either the “need” will be questioned, or the “solution” will be considered inadequate

(ii) Inclined to see far more problems with the use of a new innovation than the producer’s employees

(iii) likely to identify at least as many potential detriments as benefits if the Innovation is deployed

(iv) Willing to propose a number of changes to the prospective innovation that should be designed into it before it is deployed.

4. Research on an overview of the laws and regulations applicable to this proposed innovation. Does it comply, are there any changes that are necessary or advisable, what are the consequences of existing or emerging detriments.

In all likelihood there are several respects in which the prospective innovation does not comply with either existing laws or regulations. Across jurisdictions the number of such infractions will certainly multiply. A competent engineer with no connections to the producer could certainly propose changes in design that would pass compliance AND function quite adequately.

In addition to compliance corrections, there will undoubtedly be additional changes that would markedly improve either the functionality or the acceptability of the product. Less style, more substance, would be one type of recommendation. Another would be additional features that would address the “problem” more completely.
Usually the only “future needs” a producer will address are those based on wishful thinking, rather than knowledge of consumers. Detriments often only emerge after prolonged and widespread use – producers prefer to ignore these prospects, and leave it up to governments and/or communities to deal with such “externalities” as the need arises. Changes in design or use could also forestall many of these problems.

What about the techniques that would be used to investigate the above aspects of these needs? They will vary depending on the prospective innovation, the projected size of the market, the wider social context, and the mix of benefits and detriments that are disclosed as the Needs Assessment unfolds. Some of the following situations are likely to occur:

- Part way through the Assessment a new detriment will be “discovered” which will prompt those in charge to redefine “the Problem,” and then re-do previous phases based on the implications of this new factor
- Disagreements will arise between various of the Assessment participants, about what to emphasize, or how to investigate, which recommendations to prioritize, or who should be responsible for assuring follow-through
- Representatives of Producers, Consumers, Experts, and Interest Groups will attempt to influence the Needs Assessment outcome by lobbying for political pressure to be brought on the assessment process

To assure independence, it would be advisable to arrange that the Needs Assessment process is conducted by an arms-length agency of the government, so that the results are unbiased and trustworthy.

When a proposed technology is “assessed,” the performances of those who produced the design are being “reviewed.” Many people feel “uncomfortable” with this review process. The “secret” is, in the words of a very wise consultant, not to take it personally.” Many of us, much of the time are going to be accountable for what we do – learn to live with it! The point about Technology Assessment is to improve the technology, nothing more. If it becomes more, take the time to re-gain focus – remind everyone this is political process, not a personal vendetta.
THE DESIGN PROCESS

Once the various aspects of Needs Assessment have been performed (or not), the Design Process begins. What occurs is an attempt to translate a concept into a usable product, whether of the “goods” or the “services” variety, or some of both. How this is done has changed multiple times in many cases, depending new scientific knowledge, newly developed materials, continuously improving techniques, and emerging social and economic trends.

One of the original injunctions to consumers was the adage “Buyers, beware!” What this saying implied was that it was the responsibility of consumers to (1) accurately know what they wanted, and (2) inspect what was offered for sale to assure themselves that it did, in fact, meet their requirements WITHOUT the prospect of too many or too serious detriments. Shoddy and unsafe offerings led to political pressure, which eventually forced governments to establish and enforce safety standards.

Many companies are still notorious for either trying to ignore such requirements, or meeting them in the most minimal way possible. When product failures or malfunctions are only minor, or the products themselves are reasonably easy to replace, poor performance may be annoying but it is often tolerated. When unsafe or unreliable products could jeopardize “life or limb,” or cause extensive damage of other kinds, the implications for consumers and producers are far more serious.

Besides the malfunction of particular products, there are also “system failures” where a larger part of some infrastructure stops working and/or ruptures and wreaks havoc on its surroundings. Industrial accidents are the result (atomic power plant melt-downs, chemical plant explosions, bridge or building collapses, toxic waste leaks, etc.). For all of the above “problems,” the question is, could better design have lessened or avoided these incidents?

A new approach to design has been developed to specifically address such malfunctions. Analysis revealed that many (most) product designs were too complex, which rendered the patterns of operation confusing and uncontrollable, especially under heavy usage or emergency conditions. If products and systems were redesigned so that components were “modularized” (each part was distinct) AND the component interconnections (interfaces) were standardized, then malfunctions could far more easily be spotted, AND faulty components could be replaced.

Modular Design soon was recognized as such a powerful technique, that it was also applied to Decision-making and Organizations. The computer industry has used it extensively, but it has been slow to catch on in many other industries and contexts. It could however, become not only the basis of better designed products, but also the platform for an effective Technology Assessment process. What follows will give an outline of how that can happen, and why it needs to be done.

What Technology Assessment involves is applying a check-list of requirements and concerns to every proposed innovation. The check-list would cover aspects of both Design and Deployment. In a general sense, the same kinds of considerations would apply to all prospective innovations. Furthermore, the check-list would be readily available, so both consumers and producers could use it to plan any
“technology assessment strategies” they thought were suitable. Since Design precedes Deployment, the Design aspects would come first on the check-list.

DESIGN META-RULES TO ENABLE TECHNOLOGY ASSESSMENT

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<tr>
<th>Interfaces</th>
<th>Interactions</th>
<th>Modifications</th>
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<tbody>
<tr>
<td>Standardize connections between all types of components</td>
<td>Clarify component functions and interactions</td>
<td>Change individual components rather than entire designs</td>
</tr>
<tr>
<td>Make component connections robust</td>
<td>Separate action (what to do) and logic (how to do it)</td>
<td>Check design to ensure robustness and to separate action and logic</td>
</tr>
<tr>
<td>Examine results of component connections on system functionality</td>
<td>Check for interactions that are coincidental rather than functional</td>
<td>Design system redundancy to cope with malfunctions</td>
</tr>
<tr>
<td>Examine results of component connection failures</td>
<td>Check with interactions that interfere with functionality</td>
<td>Design system feedback to report on functionality impairment</td>
</tr>
<tr>
<td>Examine whether interfaces interact and if so, how, and to what effect</td>
<td>Check the results of interaction overload on system functionality</td>
<td>Design feedback to report impending failures or overloads</td>
</tr>
</tbody>
</table>

All of the considerations in the boxes are part of the Modular Design approach. The basic premise is that if products and systems are composed of components that have compatible interfaces and functional interactions, then any malfunctioning components can be readily identified and located, and easily fixed or replaced. So, entire systems do not have to be decommissioned or rebuilt, and functionality can be restored. If need be, functionality can be changed to include new requirements by altering the design of components, so long as the standardized interfaces with other components are retained. Modular Design will facilitate better functionality and quicker re-design should the need arise.

The remainder of Chapter One will “unpack” each of the above boxes to provide a brief overview of the objective and the process involved. Once the transition is made to this paradigm of Design, both the initial design process, and most necessary modifications later, can all be accomplished in shorter time and with less cost. So when Technology Assessment indicates that some aspect of a product design should be changed, it will quite likely be possible to re-design and reformate the product by giving attention to the specific components involved, rather than having to discard the entire product and start design and development all over again. That should serve the needs of both consumers and producers.
Chapter Two
INTERFACES

A crucial aspect of Modular Design is the task of specifying and designing Interfaces. Once the various elements have been assembled as a set of components, these components must work together to provide functionality. This “working together” is facilitated by the connections between components, and in Modular Design these Interfaces are limited in number to confine interactions to only those required in the specifications. The aim is to eliminate accidental or coincidental interactions, because these are the sources of unneeded complexity and many undesirable malfunctions.

Making such changes however, is often easier said than done. Designers may not even be aware of all of the potential or actual interactions within their designs. Furthermore, any design changes could lead to additional or different interactions, some of which may not be foreseeable, and others seem to push the bounds of credibility! Just as the word “safety” is the mantra of consumer concerns, the word “testing” is the guideline for design changes. The more possibilities are reviewed, the fewer unpleasant surprises are likely.

Since there is usually a time-frame for designing, prototyping and re-designing, designers and testers often have a sense, if not specific instructions, to “keep up the pace.” Expectations within the company include production schedules and marketing strategies as well as functionality requirements. As a result, perhaps just the most obvious design concerns get the majority of attention. Interactions which might be considered unlikely, or unimportant, may simply be ignored. In some cases this may be acceptable because such interactions have not been reported, or are of no concern anyway. Nevertheless, surprises can occur, which is precisely why Technology Assessment has been developed.

One of the tasks of Technology Assessment is to determine if the product or system interfaces are optimized regarding design, location, and functionality. Interfaces that are unneeded may mean more time and resources went into design than necessary. Extra interfaces also provide more channels for the propagation of malfunctions. Innovation proponents should be able to show the rationale between product or system configuration and its functionality. That way its security, user-friendliness, etc. can be rated in terms of its performance.

This would lead to such questions as: Does the product or system solve the problem it was designed to address? Does it perform in a cost-effective way, regarding both developmental and operational costs? Do the interfaces make the right connections for proper performance?
STANDARDIZED INTERFACES

The connection between light bulbs and the sockets they screw into or snap into, are interfaces. Prior to World War I, every manufacturer created their own socket sizes so that when consumers started using their particular products they were “locked in” to that supplier for all additional light bulb or socket replacements. Governments forced standardization on that industry and many others when they had to acquire and use war supplies across and between many locations and applications. By the advent of the computer industry, interconnections were far more readily standardized, although it still does take considerable negotiations.

Standardized interfaces start with specifications. Both within components and between components, the types and sizes of “elements” should be as few and manageable as feasible. There will, of course, be trade-offs between functionality and serviceability, but this is true of most products. Other than to provide for functionality and serviceability however, interconnections sizes or types should NOT be proliferated for stylistic or commercial reasons.

Think about the interfaces most frequently encountered: cords plugging into outlets, keys sliding into locks, door frames between the door and a wall, light switches to turn the light on and off, a nut which screws onto a bolt, a sliding door between to spaces, etc. Even some of these are more complicated than they need to be. One wag likes to claim that “there is nothing so simple that it cannot be made more complicated!” When it comes to the interior design of products and systems, both the possibility and the likelihood of interface complexity increases noticeably.

Part of the rationale for such internal complexity may be functional considerations. On the other hand, it may simply be part of a design/engineering tradition that uses complexity to exclude outsiders from understanding or tampering with the product so as to create and maintain a “closed shop” of those qualified to make design changes and operational adjustments. When this strategy succeeds, those who are the only ones “qualified” to design, install, or maintain the product are in a position to charge a professional fee for their services.

Often however, internal complexity has ramifications that even these professionals do not foresee. We will get to that issue later, but for now the point is that standardized interfaces serve the interests of both producers and consumers better than a plethora of different couplings. Purchase and inventory costs are less, schematic understanding is improved, and modification possibilities are easier to implement. The lesson from this is to reduce the number of types of interfaces to the minimum necessary to achieve functionality, and within the set of types, standardize them all so that equivalent elements can fit into all appropriate components.
The interfaces that have been dealt with so far, are those involving couplings between elements, components and systems – just more elaborate versions of “the plug fitting into the outlet.” But there is another series of interfaces that involve entirely different considerations. These are the interfaces between the products or systems and the users. “Ergonomics” is the technical name given these interfaces. They are often the result of an even worse design process than that which went into creating technical components.

Donald Norman has spent a good many years explaining and demonstrating what effective “people-technology interfaces” should amount to. In The Design of Everyday Things, he shows how even door handles are often poorly designed.¹ What is the “standard” for this kind of interface? The term Dr. Norman uses is “affordances” – these interfaces should be structured so that the intuitive sense most people have about “how the product works” when they encounter it, is exactly how it does work. If they see a handle that their intuition tells them to “push,” then that should be a “push” handle; if they see a “pull” handle then that should be a handle to pull. Research has revealed that each culture has its own affordances.

Nineteen years later, Dr. Norman published another report on his continuing research, this time titled The Design of Future Things.² This time his scope has widened to include the human interfaces with larger systems. Regrettably, the findings are just as grim. Now that computers and other forms of artificial intelligence are designed into many products, these products try to second-guess their human operators and take control of the situation without the person’s permission or approval – artificial intelligence has apparently never heard of the concept of “affordances!” If you are struggling with your car on the highway because it is trying to go in one direction while you are trying to go in another, you may very likely conclude that what is claimed to be a “helper” may be a very real hazard instead!

Operators of industrial equipment and systems may have little or no accurate concept of how the internal functioning actually works. They likely have an indicator panel and a few controls, but malfunctions may not show up, or may be misidentified. If they initiate the “prescribed response” to a malfunction signal, it could very well worsen the situation – on the other hand, if they do not respond, THAT could worsen the situation – this is often how industrial accidents occur!

Standardized interfaces which are as simple as is feasible and as understandable as possible, need to be designed into every mechanism used in our society. Neither users nor operators should be placed at a “coping disadvantage” because of design negligence (and that is exactly what it is!). Technology Assessment should flag every instance of this kind of situation and insist that it be rectified.

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ROBUST CONNECTIONS

Just as important as standardization, interfaces should be designed robust enough to handle the “wear and tear” to which they are subjected during operations. The electrical outlets in the walls of many of the apartment buildings, are regularly breaking or falling out of the walls! The plastic on the receptacles is flimsy and prone to cracking after a short product lifetime. Can-openers often break or fall apart. Door handles won’t turn. Window latches get stuck, or break off. An inventory would probably identify hundreds or even thousands of these non-robust interfaces. If the result is inconvenience, many people will tolerate it, but if serious harm could result, the stakes and the demands for more robust products are much more likely.

Many industrial accidents or personal injuries occur because interfaces are not robust. Usually an interface will be designed for a certain “load” of use – maximum or minimum levels of current or voltage will be the loads between which the interface will operate. If the load is less than the minimum, the connection simply won’t function. If the load is higher than the maximum, the connection will be “fried!” Either way the functionality of the connection will be lost.

If such an interface provides connectivity for an important control parameter, the product or system may either shut down, OR fun wild! Both alternatives could jeopardize either persons or property, or both. If the control parameter is guarding against something bad happening, and control is lost, the protection is eliminated. Brakes can stop a car before hits a rock, or a tree, or another car – without brakes, the car, the passengers, and others in the vicinity are in trouble.

If the control parameter is there to ensure that something good and necessary happens, and control is lost, the product or system could continue functioning without such “good assurances.” If an airplane’s altimeter no longer registers loss of altitude, the plane could be descending without any awareness of impending danger. So, if operators are relying on a feedback system that is malfunctioning, they could continue operations until safety was radically compromised. That is also a source of many accidents and mistakes.

Functional mechanisms are composed on a number of elements and components that must operate in an integrated fashion in order for proper functionality to begin and continue. What permits “integration,” are the interfaces between the elements and components. Hence, a standard for robustness should also be defined and implemented. What level of system loads should be expected and permitted for operation of the interface to continue?

To answer the question of appropriate load level for an interface, the range through which typical functioning occurs, should be charted. This should not be a “guess,” nor should it simply
be a reiteration of the previously specified “permissible load.” How often does the interface load actually exceed or fall below the “permissible load?” When that has happened, what has been the effect, on the interface and the product or system? Can and should the interface allow interaction outside of the “permissible load” levels? Whatever loads the interface allows, it should be able to withstand. Once allowable loads are contravened, how should the interface respond? Should it “burn out,” or cease functioning, or somehow shed the excess load in some pre-arranged way? If the functionality the interface supports is crucial, these questions should be asked and answered.

The other type of interface, involving Ergonomics, should be robust. User interfaces often perform in an erratic manner. Clicking on-screen buttons does NOT always engage the functionality that the software is supposed to deliver. If that happens to a GPS while the driver is seeking destination directions, the vehicle might conceivably be directed almost anywhere! Or what if the computer screen is part of the control apparatus for an atomic power plant or a chemical processing factory?

People who are at an interface with technology are often trying to exercise some degree of control, and simultaneously getting some “service” as part of the process (this service may simply be information about the behavior of the technology). People who engage with technology usually “intend” to achieve enough control to accomplish the objective for which the technology is a means. If and when that control is jeopardized or evaporates, people often feel a sense of panic or dread. Perhaps the plane or the train is going to crash! Perhaps the plant or the factory is going to blow up! Such prospects may be unsettling enough to prompt irrational behavior, leading to an even worse outcome than was initially going to happen! If there was ever a compelling reason for robust user interfaces, this is it!

What can people reasonably expect from a user interface? Firstly, appropriate affordances for the majority in the local culture. Secondly, reliability of operations, so that the “service” promised is delivered, and conflicting, contradictory or irrelevant “services” do not intrude. Thirdly, some feedback on how the technology is coping with the person’s request. And fourthly, some suitable warning about any pending functionality failure(s). Actually, numbers two, three and four are just more sophisticated versions of affordances. As well as Artificial Intelligence, technologies also need to be equipped with Artificial Sensitivity, so that people can develop some rapport with them, so that control can continue to be shared rather than the technology trying to pull a coup during emergencies!

Interfaces are what empowers technologies to function and people to use that functionality. Unless we are planning to create a world ruled by Transformers, designers need to dedicate themselves to assuring that both sets of interfaces perform appropriately. The role of Technology Assessment should be to remind producers that products are not an end in themselves, but rather instruments to serve human purposes.
CONNECTION CONSEQUENCES

What effects, if any, do a product’s or system’s interfaces have on each other? If, during certain forms of functionality, a number of interfaces are engaged simultaneously, does this affect performance in any ways beyond what is technically specified? If there are such effects, do they enhance functionality, or depress functionality, or are the effects functionally neutral?

Does anyone ever investigate any of these possibilities? Not likely! Occasionally however, an operator or other user will twig to the fact that under certain operational conditions, the product or system performs better (or worse) than usual. The problem with these kinds of conditions, is that they may exhibit entirely “new” patterns of behavior under circumstances which are rare, but still entirely possible.

Do individual interfaces have what appears to be an “exaggerated” effect on product or system functionality? Are these “individual effects” positive, or negative, or neutral? Perhaps some interfaces would be found to have positive effects, others to have negative effects. How would the simultaneous occurrence of some positive and some negative effects, affect functionality? Would the overall effect be a cancellation of positive by negative, or would one or the other be enhanced, and perhaps interfere with some aspect of functionality?

Does anyone ever investigate any of these possibilities? Occasionally, but rarely! Usually both designers and users are looking for evidence of functionality that can be the basis of a sales pitch. If occurrences fall below a certain threshold of probability, they are usually ignored; that is what leads to many product recalls! But operators and/or users may demand performance from a product or system that was never really intended or anticipated by producers or designers; that is what leads to many industrial accidents!

One example of such a situation is one that would not “normally” be considered in this framework. Many of the new medicines and drugs developed these days consist of a “bundle” of various chemical constituents. Such constituents are supposed to act together in a complementary fashion, to the benefit of the user. However, the user’s own particular health situation (or unhealthy situation!), may interact with the chemical constituents in the bundle to provoke harmful, even deadly reactions.

This latter turn of events has now happened often enough that producers are issuing warnings about “the conditions of safe use.” There are usually so many complications that it is a wonder that there is a large enough market to recoup the costs of development. What such medicines and drugs lack are suitable “interfaces” that would internally control the activation of each of the chemical constituents. “Nano-medicine” might be able to eventually create bundles of
constituents that could self-regulate every ingredient’s activation, so that it would only engage if the user’s state of health was suitable. They are probably working on that right now!

Much of the rationale for Technology Assessment arises from the occurrence of unanticipated effects and impacts of technologies. The causes of these effects and impacts are often aspects of design or operations that were ignored or misunderstood. Tightly coupled designs aggravate such problems because elements and components within the products or systems interface and interact in multiple ways. People have notorious information-handling limits, and complex products and systems entail too much information for users or operators to cope with. THAT is the rationale for Modular Design. IF functional components only interact through a limited number of interfaces, control of their operations and coping with their effects, are far more likely.

What will also be much easier, is to test the operational effects of various combinations of interface engagement. In some cases, effects may depend on the number of simultaneous interface engagements. In other cases, effects may depend on the sequence of engagement, or the duration of engagement, of some combinations of numbers, sequentiality and duration,

Why does it matter?! Because, the right (or the wrong) combinations could lead to various kinds of disasters involving personal and/or property damage. As Professor Charles Perrow has found in his research, even correctly and properly performing technologies can still produce effects that are unexpected and unwanted.¹ In the past, some of these incidents have led to catastrophes (Three Mile Island, Bhopal, etc.), and unless the basis of design is changed, there will be more catastrophes!

It is also likely, of course, that some of the component connections will produce welcomed enhancement effects. The proper architecture of interfaces could be found to improve the speed of performance, decrease the energy needed, improve certain aspects of control, and reduce the likelihood of certain types of malfunction. Once these effects become ascertained, techniques based on their application can be added to design methodology.

The point about technology deployment and use, is that responsibility for the product or system does not end when they are shipped or delivered to customers or users. The era of “buyer beware” is gone, even if some producers still implicitly behave that way. Technology Assessment has been created to ensure that the entire product and system life-cycle is provided for. The role of governments is to protect citizens from harm so far as this is feasible, and Technology Assessment is one instrument for that purpose. The growing electronic interface between citizens and governments will just reinforce this responsibility!

CONNECTION FAILURES

What are the causes of connection failures, and what are the results? A contributing structural cause, namely interfaces that are not robust enough for the job they normally have to do, was previously dealt with in ROBUST CONNECTIONS. Nevertheless, there are undoubtedly other causes of interface failure as well.

One such cause would be careless handling by producers, users, or maintenance and repair staff. Perhaps certain sections of elements or components are relatively delicate or prone to damage unless handled with due diligence. Some of those who do handle these parts may not be aware of proper handling procedures, or may “just not give a damn!” A third alternative is that some of these parts may be accidently broken or damaged, without that necessarily being readily apparent to those handling them. If such damage occurs “in place,” no one may be the wiser and the product or system may be used on the assumption that “everything is fine.”

Another cause, often attributed, is use overload. Too many operations occurring simultaneously, or the product or system is pushed to operate too quickly, or the duration of operation is too long, or the proper maintenance and repair checks are not properly adhered to, or the product or system is not used for an extended period of time and not given a test run before attempts are made to put it into use again. Different forms of overload are responsible for all of the failures in such cases. What is often forgotten by users and operators is that elements, components, products, and systems all have “usable lifetime limitations” intentionally or inadvertently built into them. Past that usable lifetime, what was previously a normal load can become an overload.

The most dubious “cause” of all, according to Professor Charles Perrow is “user or operator error!” When design or engineering or manufacturing oversight or negligence are likely causes, those responsible look around for someone else to blame. The most obvious and easiest targets for that blame are users and operators of the technology. Part of the challenge that users and operators face, is their training to properly use the product or system may be minimal or non-existent. This can be compounded by product or system upgrades for which additional training is also inadequate. Forensic investigations of accidents often reveals that the actual cause of a mistake or accident could not have been anticipated or handled by ANY user or operator!

To follow up on this last point, how can technological challenges occur that are completely unanticipated and entirely misunderstood? The same way that surprises occur in political, and social, and economic, and personal relations all the time! Problems can “emerge” because relationships involving people are often “non-linear” in their causes and effects. Incremental increases or decreases may have only gradual, minimal effects UNTIL a critical threshold is
reached. After that the effects may be both very fast and very great. What previously looked like a stable situation, can then “go all to hell.”

Related to this non-linear situation, is the recognition that connection failures may occur through no fault of either the designers and producers or the users and operators. Bad weather (humidity, or heat), fire or flood, infrastructure failures elsewhere (a building or bridge collapsing), or a traffic or industrial accident may damage a product or system directly, or indirectly by preventing a critical supply flow (electricity, water, sewage, information). Any of these may result in interface failure, for which nothing very immediate can be done, UNLESS backup provisions have been built into the product, system or situation. THAT may also be something that Technology Assessment could recommend for certain critical technologies.

The bottom line is then, that connection failures can have results which range all the way from minor and minimal, to major and maximal. Furthermore, a situation that caused just a minor blip one time may cause a major failure and disruption another time. According to Professor Perrow’s research findings, the reason many more accidents and disasters do NOT occur seems to be more a matter of just plain “dumb good luck” than any intentional behavior. Often accidents result from a coincidental occurrence of several minor causes that usually do not pose any threat UNLESS they occur at the same time and place through bad luck.

Therefore, interface failures should be anticipated and planned for, in terms of the size and implications of the disruptions they produce. Regarding size, small, medium and large may be enough of a differentiation to cover contingencies. Implications are qualitative rather quantitative, so the appropriate categories might be minor, significant and major to cover this range. If there are critical indicators or results, they could be the basis for coping with failures.

The crucial questions would probably be:

1. How important is any particular interface to general functionality?
2. How important is general functionality goals and objectives?
3. Can the interface be immediately fixed or replaced?
4. Can functionality be restored without a particular interface?
5. Could a better designed interface handle this problem more effectively in the future?
6. Could redundancy be used to circumvent this kind of challenge in the future?

Any additional questions that would apply specifically to a particular interface or technology, could be readily added to this list. Depending on the answers developed to such questions, provisions should then be made to change the interface design and/or the operating procedures that would be used in the event of interface, technology or system failure. Although a particular installation may never experience a serious interface, product or systems failure, some of that type surely will. From the point of view of prediction, occurrence is mostly random. Therefore planning, provisions, and training for all users, operators and managers is needed.
INTERFACE INTERACTIONS

Although interfaces connect elements and components so that these elements and components interact to produce functionality, do interfaces interact with one another, and if so, how and to what effect? Could interfaces interfere with the functioning of other interfaces? Could interfaces enhance the functioning of other interfaces? Could clusters of enhanced functioning interfaces enhance OR interfere with the product’s or system’s functionality? Could interfaces jointly effect aspects of a product or system outside the range of their own functional roles? What would the nature of any of these interface interaction effects likely be?

Most designers, users or operators would likely dismiss such hypothetical effects. Hence, their possible occurrence would not be studied or explained. Incidents or accidents that might be caused by these effects would therefore appear as “mysterious” or be attributed to some completely irrelevant cause. As Professor Perrow’s research showed, such complete misdirection happens quite frequently, although it is denied quite vehemently! Very few specialists are comfortable admitting complete ignorance of an important part of their field of operations.

If by chance, some reliable evidence of such effects is ever discovered, most of those implicated will claim that the effects, the results, and the entire complexion of events entailed, are completely new and beyond any reasonable person’s purview. As I was advised as a young man, if suspected of any complicity, “deny, deny, deny!”

The majority of technological interfaces function to provide mechanical and/or electrical and/or informational connections to elements, components, products, systems and people. There may be additional tasks interfaces would perform, but other than being a “spiritual channel,” I cannot even guess what they would do, and “spirituality” is not considered a functional operation anyway!

Once interfaces are viewed from this functional perspective, the details may be endless, but the generalities are suitably specified. The “problem” with interface interactions is that, in regards to their specified functions, they are doing either MORE or LESS than what was intended. So, for instance, a mechanical connection might also conduct heat or electricity, not because that was intended but because of its proximity to sources of heat or electricity! Or an electrical wire might also provide a mechanical connection between elements or components. Assurances that “we have taken precautions against this,” do not explain how it happens anyway!

One way an interface might influence one or more other interfaces, would be if an interface supplying electricity were overloaded with the result that it burnt out and thereby stopped the power supply completely. That could shut down the remainder of the interfaces and all of the
other components as well. Similarly, if an interface providing a mechanical link were to break, the structural integrity of the product or system, including other interfaces, might be jeopardized. If different interfaces had different upper load levels, a robust interface could feed too much power to other interfaces with lower load limits, and that might burn them out, or cause other forms of malfunction.

Heat conducted through a mechanical interface might overheat either electrical or information interfaces, leading them to burn out or otherwise malfunction. Too much electrical current coming through an electrical interface might “leak” to other electrical interfaces and overload them, or the leak might interfere with information on an information interface. Too much heat or power leaking from any interface might cause other components to melt or malfunction, interrupting the entire functioning of the product or system and causing it to shut down.

So, various kinds of interactions through various kinds of interfaces could be the sources or the recipients of trouble, in ways and to an extent that is rarely studied, understood, or precluded through design. Modular Design would make it much more feasible to eliminate most of these causes of trouble. The reason there are not more accidents and malfunctions with tightly coupled designs, is that same old “dumb luck” again, rather than design finesse.

Modular Design itself was “designed” to deal with the many problems that interfaces are subjected to in more complex, tightly coupled designs. The fewer connections between elements and components, the fewer channels to pick up or pass on trouble-producing interactions. This being the case, the role that interfaces play in both loosely coupled designs (Modular Designs) and tightly couples designs (Complex Designs), is vitally important. Products function because elements and components are connected and “work together.” But malfunctions also spread because elements and components are connected and “work together.” Therefore the goal in design is to configure the elements and components so that functionality is enabled but malfunctions are disabled.

The role of Technology Assessment in this regard, is to examine the design and performance of products and systems, and to assess how the existing design enables performance, AND possibly how changes in design could improve performance. If interfaces are not robust enough or reliable enough for the job they are doing, then improvements in the design of interfaces can be recommended. If the designed configuration of interfaces could lead to malfunctions and/or damage, then improvements in the configuration of interfaces can be recommended.

In this, as in all other Technology Assessments, the primary concerns are user and operator safety, and product and system security. Interfaces are crucial components because they spread effects through a product or system. When the effects are good, you get functionality; when the effects are bad you get malfunctions and/or damage. So design accordingly.
Another important aspect of Modular Design is the quantity and quality of Interactions between elements and components within the technology. Intended Interactions are specified because they are the actions that produce the functionality. In tightly coupled, complex designs however, there are often many unspecified and unintended Interactions due to the proximity of many elements and the proliferation of Interfaces. One of the aims of Modular Design is to reduce interactions to the minimum necessary to ensure functionality, and to eliminate random and coincidental Interactions wherever feasible.

It is the interactions that, if allowed to proliferate, create complexity in the technology. With “integrated design,” the situation is seen as inevitable because “integration” is believed to be “a good thing.” However, past a very preliminary point, this integration produces complexity, and that compromises functionality. Most of the arguments in favour of integration simply contend that this chain of events is unfortunate but unavoidable.

The “problem” here is the paradigm of design that sets the context for particular product configurations. It was Thomas Kuhn who pointed out that within science, this kind of “limited options perspective” was what eventually led to “paradigm change” – if experimental results could not be explained by an existing paradigm (theoretical framework), then someone would eventually propose a new paradigm that could deal with the new facts. Engineering appears to be confronted with the same kind of situations. “Modular Design” is that new engineering paradigm.

When and if a Technology Assessment finds too much configuration complexity, and as a result, too many Interactions that could lead to malfunctions, then the appropriate recommendation to make is that such Interactions be reduced. Not surprisingly, the most effective way to accomplish this is through Modular Design. Unlike human interaction which is a good thing, component interaction within technology is only desirable when it contributes to functionality. If interaction is unspecified and unintended, it represents more risk than it is worth. Limit it.

Modular Design involves locating functionality within identifiable components. Interactions will only occur (if properly designed) through the specified interconnections, and these will be designed to limit and control those interactions so that they contribute to particular types of functionality, and nothing more. When and if Technology Assessment find interactions problems within a technology that lead to malfunctions, the appropriate recommendation is to change the basis of design, because that is what is producing the problem! Otherwise there will be a never-ending stream of complexity-induced malfunctions.
COMPONENT INTERACTIONS

Interactions consist of reciprocal actions, effects, or influences – in other words, each is responding to the other(s) during a task or encounter. Components have functions to perform – some of those functions involve interacting with other components to produce joint or mutual effects. Other instances of component interaction may not be planned or functional, but may occur nonetheless.

To conduct a component audit, it is necessary to indicate all of the components’ functions, all of the interactions, when the functions and interactions concur and when they don’t, whether the effects of the interactions are actually functional, and what are the results of the interactions when the relationship is not functional? This is certainly a topic which will hold a number of surprises – designers, users, operators, and managers will all learn of interactions and consequences that they had previously not encountered or realized. Some of these possible interactions could be the sources of malfunctions, harm and damage, to the product or system, to people and/or property, and to the environment.

When an unknown interaction is discovered, whether beneficial or detrimental, knowledgeable observers will often exclaim, “Hey, that’s not supposed to happen!” But component interactions, like people interactions, do not always behave like they are supposed to. An audit will likely take considerable testing, and access to the reports of previous tests and performance.

The place to begin this audit is with a delineation of the functions each component is intended to perform, AND the functions that joint or mutual actions are intended to perform. Does any component or group of components perform any functions they were NOT intended to perform? If there are redundant components or capacity, perhaps some components are serving as back-up when other components fail or malfunction?

Do any operations of the product or system actually jeopardize any functions or interactions? The fact that such a situation was not intentionally designed into a product or system, does not mean it can’t happen. With this kind of situation, if it
happens at all, does it pose a minor or momentary impairment of function, or does it represent a major or long-term threat to functionality? Do regular aspects of function interfere with any components? All of these questions are relevant because users and operators are using the product or system to accomplish certain objectives. Impairment of function could mean failed objectives and possible harm to persons or environment or damage to property.

Modular Design specifies that various aspects of function be localized in specific components. Have all of the functions of the product or system been specified? Does the total set of functions specified perform to achieve the objectives that the product or system was designed to accomplish? Given the objectives, are there any functions missing, or inadequately provided for? For instance, if one of the objectives was to give a warning, but the generation of that warning signal was unreliable, then the warning function has been compromised and is inadequate.

On the other hand, is some of the functionality superfluous to the intended objectives or proper operations? Sometimes designers get “carried away” and over-design a product or system just to “show off!” Producers may stick with such over-design in an attempt to generate approval through association with symbolic values, but such extras contribute little or nothing to solving the problem the technology was mandated to address. Since the phenomenology of “function” is to address a problem with a solution, extra capability which is irrelevant to the problem or to performance reliability, is just another form of waste!

Clarifying functions and interactions provides a basis for delineating whether elements and components meet objectives through functions, and whether connections and operations interact so as to enable proper performance. In other words, this gives Technology Assessment a method for enquiring if the product or system is doing the job it is supposed to, AND at the same time operating in a safe and secure way. Does it (the entity being assessed) do the right things, and are these thing being done in the right way? Any discrepancies found are the basis for recommendations to rectify the shortcomings.
One of the characteristics of Modular Design is the practice of separating “what the module does” (the actions), from “how the module accomplishes the actions” (the logic). By distinguishing between objectives (what) and procedures (how), it becomes possible to shift focus from larger and longer-term strategy to smaller and shorter-term tactics, or visa-versa depending on the design task getting the attention.

One important point to remember about the separation of Action and Logic, is that most users of products and/or systems are NOT interested in the details of the Logic, but rather are concerned about the results of the Action. Users are members of the general public, which for purposes of this discussion are those with little or no knowledge of the technicalities of functionality. On the other hand, designers and operators are specialists to one degree or another regarding the product and/or system, so they have an interest in knowing the technicalities sufficiently well to perform their jobs.

Some specialists delude themselves that there is a large untapped demand for more details (this is largely wishful thinking), while others regard widespread technical illiteracy as a consignment to second-class citizenship (this is largely snob appeal). When members of the public do display an interest in a certain technical topic, it is usually to pursue a personal objective – for instance, a person learns a little about the law after being charged with an offense. As for achieving technical literacy, it takes the kind of sustained focus which many people are temperamentally unsuited for, and specialists try to limit access to anyway.

From a practical point of view, it is entirely sufficient for the public to focus on the results, outcomes or consequences they desire when using products and/or systems. It is the operators’ job to make the product or system perform properly, and it is the designers’ job to make the product or system function properly. If this reads like assigning too much responsibility to specialists, a more careful reading is needed. The key word in both of the above job descriptions is properly. Achieving this becomes problematic when the expectation is for too much functionality for too low a price (consumers), or too little functionality for too high a price (producers) – you can’t have it both ways!

Because of these conflicting mind-sets from producers and consumers, the only general AND on-going basis for mutual satisfaction, is negotiation. This can be handled by a version of Cost-Benefit Analysis. Producers want to reduce expenses (costs). Consumers want to increase what the products or systems will deliver (benefits). Trade-offs are inevitable. Those who try to disguise “trade-offs” with other names are merely deluding themselves and others – the bottom line is that both sides have to compromise when seeking their objectives. (Nobody ever said [credibly] that this would be easy!)
Is all of the above explanation necessary? YES, because the place to start “managing expectations” is **with your own expectations!** So, what can product and system design realistically do regarding Modular Design, separation of Action and Logic, and trade-offs between Costs and Benefits. The answer can be found in the concepts of Strategy and Tactics. Why is all of this relevant? Because in Design, context is as important as content. Designs do NOT appear by magic – they coalesce from the conjunction of need, opportunity, ability and ambition.

What does separating Action and Logic do for the design of interaction? For one thing, a functional objective may be provided using a number of different processes. By the same token, a process may be used to support a number of different functional objectives. So, the more that is known about the Action and Logic of interaction, the more that can be done design-wise. The way to acquire that knowledge is, of course, through learning:¹

- Incremental learning can lead to functional changes
- Modular learning can lead to component changes
- Architectural learning can lead to product changes
- Radical learning can lead to systemic changes

Once again, this knowledge of interactions is not only a contributor to Design, but also to Technology Assessment. When examining a producer’s proposal or prototype, are the Action and Logical aspects of Interactions suitably delineated? Are Action and Logic being treated separately so that they can be mixed and matched to provide functionality through most efficacious Interactions? Have the obvious (and not so obvious) alternatives been tested to determine which arrangements are the most efficient, most robust, most reliable, etc., If there are trade-offs, how were they arrived at, and do they perform acceptably on all parameters?

Only are rare occasions will the answers to all of these questions be optimal, or even available. It therefor becomes the role of Technology Assessment to suggest what variety of additional learning is appropriate to form the basis for some further design work on the proposal or prototype. What more functionality, reliability, safety or security needs to be “designed in” to the Interactions so that good performance is more likely and malfunctions are less likely? To anyone who might object that this extra design work will require either too much time, or too much money, or both, it is worthwhile to remember the System Analysts’ famous question: Why is there never enough time or money to do it right the first time, but always plenty of time and money to correct mistakes later on?

COINCIDENTAL INTERACTIONS

Does the combined effect of all coincidental interactions induce any results on product or system functionality? Professor Charles Perrow of Yale University has conducted research which shows that such “spill-over effects” do indeed exist.\(^1\) What makes these effects so pernicious is that they are usually completely unanticipated, and often initially completely misunderstood.

Electrical “leakage” from a number of electrical wires in close proximity, can cause electromagnetic fields that may influence the functioning of certain elements, components or instruments within the product or system involved. This is not usually recognized as a possibility, and therefore no precautions are taken to prevent interference from happening. The interference, in turn, may be a low-level constant, OR an erratic spike. Its precise effects are rarely studied because rarely recognized. If it occurs because of a power surge in an emergency, this may be the beginning of the kind of cascade effect that leads to an industrial accident of the kind Professor Perrow studied and wrote about.

Modular design of elements, components and systems would go a considerable way to reducing or eliminating such phenomena. Interactions could be designed to avoid such leakages, and that would eliminate this cause of malfunction.

Mechanical interactions can also lead to system malfunctions. Mechanical connections that are loose (have a little “play” in them) may start to rattle in resonance when products or systems operate at certain speeds or run under certain loads. Such vibrations can, in turn, shake loose electrical connections, and this can also be the beginning of electrical leaks and all that this leads to. Once again, these effects are often either unnoticed or ignored. And in the same way as described above, they can lead to malfunctions.

Yet another rare occurrence are reactions between the chemicals that compose product or system components. Mild electrical fields may break down chemical bonds, leading to eventual malfunction. Reactive chemicals from two different elements or components may interact when placed in close conjunction, thereby compromising the functionality of one or both parts.

All of the above results are “coincidental” rather than “intentional,” but that does not prevent the effects from happening. The results of “tightly coupled design” are that product and system dynamics can be very complex. In such circumstances, understanding the internal dynamics requires a transition from linear, deterministic thinking to non-linear, probabilistic thinking.\(^2\) Rare complexions of events can produce very big surprises, both good and bad!

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1 Charles Perrow, NORMAL ACCIDENTS, Princeton University Press, Princeton, 1999
2 Ilya Prigogine & Isabelle Stengers, ORDER OUT OF CHAOS, Bantam Books, New York, 1984
But, such tightly coupled designs are not usually necessary or desirable. The alternative, loosely coupled designs, are the result of Modular Design. Modular Designs reduce internal interactions and channel them through robust and reliable interfaces.

Given this capability of Modular Design, and the drawbacks of tightly-coupled designs, it behooves both designers and producers to examine their current designs for these kinds of flaws, and transition to the Modular Design process so that future products will be markedly safer and more reliable.

Although he is apparently unfamiliar with either Perrow’s or Prigogine’s work, Paul Ormerod has also contributed to this diagnosis. Most things fail because situations and circumstances change through time, so the things that were once suitable for initial conditions are no longer suitable for new conditions. So, either obsolescence is eventually experienced, or a way is found to track the changes and retrofit the “thing” so that it keeps up with changing demand.

This is another way of looking at Technology Assessment. Tracking during deployment highlights emerging detriments and inadequacies that are only apparent after extended use. That is then an opportunity for producers to either retrofit the existing technology OR design a new innovation in light of ongoing trends.

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3 Paul Ormerod, WHY MOST THINGS FAIL, Faber & Faber, London, 2005
Do some Interactions, either within or between components, interfere with functionality? In all likelihood, yes, although such results would rarely be intended or planned that way. What about any rare cases in which such interference is intended? It is conceivable that in instances of serious overload, the interactions between elements, components or modules would in some way slow functionality instead of letting a “run-away cascade” occur that would either damage the internal working of a product or system, or cause unsafe performance as an output. If such a case were found, the question to ask would be, is this the best way to handle such an emergency, or would some other design alternative be more appropriate? As far as any other kind of intended interaction interference is concerned, the same question as above should also be asked.

Far more likely are cases in which interaction interference is unintended. One important thing to find out in each such case, is the cause of the interference. Is the problem a local or systemic overload? Is some process drawing in too much electrical or mechanical power? OR, is there some kind of other problem that interferes with the power supply, and it becomes insufficient?

Do some of the Interfaces not function properly, so that power transfer from one component to another is either too small, or too great? If too great, does this in turn overload other Interfaces? If not enough power is transferred, does this subsequently starve other Interfaces, leading to a successive impairment of function as power supply declines throughout.

The dynamics involved in these types of cases may not necessarily be adequately understood. Too much power in one component may result in too little power in another component. The result may be some components trying to over-work, and others forced to under-work. Depending on where the problem starts, and the speed with which it propagates, the outcome for the product or system as a whole, may vary considerably.

“Nobody told us this would happen,” is the response of many users and operators. That could very well be because none of the designers anticipated that it could happen! When it does happen, the first task is diagnosis. Do some tests, ask around, read the literature, check the internet – see if it is possible to find any reference to anything resembling the kind of situation currently being dealt with. Concurrently with diagnosis, enquire if anybody with any experience on this type of problem, can make any suggestions about how to cope with it.

In what other ways could Interactions interfere with functionality? Could one type of Interaction interfere with another type of Interaction? Perhaps the assumption was that such different types of interaction would occur at the same time because of how the functionality was distributed throughout the product or system. If an anomalous situation occurred in which
both of these types of Interactions DID occur simultaneously, the result might be to interfere with other Interactions, and that in turn might affect functionality. A “deep knowledge” of such Interactions must enable a designer to forecast such events, but without such knowledge the designer may not be in any better position to anticipate such interference than a user or operator.

The functioning of complex products or systems sometimes results in the emergence of new and unanticipated internal dynamics or external behaviors.¹ There is no guarantee that these emerging dynamics and behaviors will have either positive or negative effects, although probabilistically speaking, the number of negative effects considerably outweighs the positive effects. Therefore, if complex designs persist, odds are they will produce unanticipated detriments. This is a further reason for practicing Technology Assessment on all proposals for technological innovation.

Once it is discovered that a proposed technological innovation has both the capability and the likelihood of producing Interactions that interfere with functionality, the challenge arises of eliminating or significantly reducing such Interactions. But how? Will anyone be surprised to read that the answer is Modular Design? Modules are designed to perform their functions without being tightly integrated with other modules. Modules also make limited contact with other modules, by way of Interfaces only. Connections are not proliferating from multiple locations on the Module to multiple other locations on other Modules. So, the opportunities for Interactions of all kinds are reduced, particularly for those interfering with functionality.

It is nevertheless conceivable that some of the Interactions through Interfaces could still interfere with functionality, but since the numbers of all Interactions have been significantly reduced, it will be far easier to test the remaining Interactions to determine if any will lead to malfunctions. Furthermore, by testing along sequences of functionality, identification of problems can be even quicker than examining each Interaction individually. Modules are designed to channel functionality through specific Interfaces for specific results, and not to permit Interactions anywhere else. This is one of the primary advantages of Modular Design.

If Technology Assessment does identify more than just a very few functionality interfering Interactions, it would certainly be advisable to point out the Interactions that must be eliminated, AND to recommend that the design paradigm being used by the producer should be “up-graded” to a Modular approach. This will save significant time and money on all future designs, two advantages which are likely to be very appealing to most producers. The results will also be safer and more secure products and system for users and operators.

¹ Ilya Prigogine & Isabelle Stengers, Order Out of Chaos, Bantam Books, 1984
INTERACTION OVERLOADS

How and why do interaction overloads occur? In many cases users and operators will be expecting to be able to derive either qualities or quantities of functionality for which products or systems are just not designed. Products and systems usually come with labels on them which specify operational limits. Only power sources of specific voltages are to be used. Operating temperature should not exceed a certain level. The housing on a product motor can only support loads up to a certain weight. Proper functionality will only occur if the correct angle of approach is used. Depending on the specific of the product or system, such limits could cover a multitude of technical considerations.

Does this stop users or operators from plugging into power sources with the wrong voltage, or running the motor at speeds that over-heat it, or placing something on top of a housing that is far heavier than specified, or using a completely inappropriate angle of approach for a tool? Apparently not if experience is any indicator! If a malfunction or an accident occurs, the possible rationalizations on the part of users or operators, are truly amazing. They didn’t read the instructions, they didn’t notice the infractions, they didn’t think it “really mattered,” they can’t understand how such a “strange” requirement applies to this product or system.

Sometimes the product or system is “under-designed” for the tasks it is supposedly specified for. According to the salesman or the brochure, a certain level of performance has been promised. However, once in use, shortcomings begin to appear. It heats up too quickly, or doesn’t draw enough power, or is too flimsy for the work environment in which it will operate. If confronted with reminders of the promises made by salespersons or brochures, attempts will immediately be made to lower expectations to the level at which performance actually occurred. “No guarantees were made,” or “you must have inadvertently exceeded the posted limits,” are two of the most likely excuses.

So, both consumers and producers contribute to the causes of interaction overloads. In addition however, some operations do not exceed any SPECIFIED limits, but overload Interactions anyway, and that can lead to malfunctions. Professor Perrow’s case studies of numerous industries and accidents, show that the design of products and systems is often the source of such problems. The more channels of connection that exist within a product or system, the more likely it is that at least some of the Interactions within a particular design, will result in both overloads and malfunctions.

Perrow’s extensive research convinced him that some of these accidents were inevitable, and hence “normal.” The problem he identified for the designers and producers he critiqued, was that they were often operating under the assumption that high degrees of complexity were necessary in product and system design. He conceded that occasionally this “need for complex design” might actually be authentic – that is to say, there were no design alternatives to complexity for certain specific technologies. On the other hand, he also maintained that in many (most) cases, producers and/or
designers were simply copying traditional approaches to design because they were already in use, and hence it was cheaper and easier than developing a radically different design paradigm.

Perrow then reviewed examples of simpler, better designed products and systems. The kinds of characteristics these “better designs” displayed were, in fact, many of the same ones that became the basis for Modular Design! In particular, components in the cases Perrow favored were loosely coupled, and hence coincidental Interactions were reduced in number AND less likely to engender malfunctions. However, it does not appear that Perrow’s critique was the motivation for developing Modular Design OR the switch to its use.

Modular Design arose in an industry (computers) that was experiencing so many complexification issues during product and system design, that an alternative design paradigm was the ONLY way the industry could stay productive and profitable.¹ Practices in this design paradigm were not necessarily easily developed or quickly accepted, but the approach did eventually demonstrate it superiority, and so spread.

Where “design choice” still exists though, Modular Design has NOT been so readily or enthusiastically accepted. The result is, that in many industries where Modular Design is not practiced, there is still far too much complexity in product and system design, too many accidents and malfunctions, AND no compelling reason to change to Modular Design because nothing nor no one is forcing the issue! Apparently, neither the government nor the public has made an issue out of the situation so far. This is a glaring example of civic negligence, much the same as the many more glaring examples of this kind in the 19th century.

Just as Modular Design could assist the practice of Technology Assessment, so also Technology Assessment could assist the practice of Modular Design. Any design proposal and prototype, of either a product or a system, if not based on Modular Design, should be re-designed with distinguishable elements and components, so that Interfaces would be reliable, Interactions would be functional, and any necessary modifications could be expeditiously accomplished.

This kind of “particular” recommendation should not only be applied to specific case where a design proposal or prototype was manifestly faulty, but should be the “general” basis for Technology Assessment recommendations to all designers and producers. When certain design approaches, in whatever industries, are at risk of malfunctions and accidents, jeopardizing safety and/or security, it is the duty of Technology Assessors to point out, in no uncertain terms, what the implications of this lackadaisical attitude and negligent behavior are, namely a flagrant disregard of civic responsibility. Although Ralph Nader’s UNSAFE AT ANY SPEED did spur the automobile industry to improve safety, many other products and systems are still accident-prone rather than user-friendly.

¹ Carliss Y. Baldwin & Kim B. Clark, DESIGN RULES, MIT Press, Cambridge, 2000
The third big advantage of Modular Design is the opportunity it provides to modify elements and components rather than having to redesign the entire product or system when changes are being implemented. During the initial design, various alternatives and options are tried out, and after experimentation and testing, choices are made. During subsequent reviews, some of these choices will have to be changed. The same thing may happen to a prototype that was previously accepted but needs some changes based on various user and marketing tests. As long as the intended Interfaces and Interactions are retained, particular changes are much quicker, easier, and less costly.

It is the slowness, difficulty and cost of design changes within integrated design that often accounts for the reluctance some designers and producers have for resisting suggestions for extensive modifications, once they have settled on a preferred configuration. Contingent on these challenges is the prospect that any extensive modifications that were made, could themselves lead to other kinds of instances of malfunction. In such a case, curing one problem might lead to other problems, and these conceivably could be larger or more disabling than what was changed.

It was dilemmas like this that prompted the search for a better design paradigm. For any number of reasons, a particular design configuration may need to be modified. Changes in consumer needs, changes in technology regulations, changes in functionality implications, etc. could suddenly create a situation where even previously adequate design solutions would no longer acceptable. If every such change requires a major undertaking, it should surprise no one that designers and producers will ignore design shortcomings and resist external suggestions.

Wouldn’t it be nice if an approach to design could be developed that would allow modifications wherever and whenever they were needed?! Well, of course it would be – but is that really possible? ONLY if the design paradigm is itself changed quite profoundly. Modular Design is that profound change.

Because Modular Designs consist of Interfaced and Interacting components, changes can focus on the specific module where modification is needed rather than redesigning everything. That is an advantage that Technology Assessors should emphasize on every available opportunity.
MODIFY COMPONENTS

Changes in design of some sort will occur in the development of every product or system proposal or prototype. Some of these modifications will be minor, others will be major. This requirement is not news to designers or producers of technology. Nevertheless, there is often a lack of a “strategic perspective” regarding modifications. Initial design proposals are often based on a “bright idea,” whether the origins of this idea are individual or collective, internal or external. This bright idea’s capacity to “inspire” some portion of design work, has the implication that it engenders commitment from one, some or all of the developers.

Regardless of the “brightness” of the idea, or the level of commitment of the developer(s), there is NO guarantee or even likelihood that such an idea is a “good” one. Probabilistically speaking, half of all new ideas will likely be bad, just are the other half will likely be good. Even the good ideas however, face other challenges. Some of them will be technically unfeasible, or too expensive to apply, or socially unacceptable. Once again, on the basis of probability, this narrows good, feasible, inexpensive, and acceptable ideas down to only 6.25% of the original “bright” ones!

Of the 6.25% that do pass the previous “tests” initially, other challenges will crop up later. Perhaps the new application contradicts or conflicts with some other factor that eventually has to be considered. Perhaps performance is not reliable, or it won’t interface properly or conveniently with something else, or it produces some contingent result while operating that is dangerous, or too expensive to correct. The bottom line is that there are many more ways to malfunction than to properly function, and these could reveal themselves at any moment throughout the development process, from first encounter to final assessment.

If in addition to producer profitability, consumer acceptability and safety regulation, those in R&D were also blind or deaf, the challenges of product or system design would be insurmountable. Fortunately, most designers are neither blind nor deaf. BUT, they are blind and deaf to the need for a transformation of the design process. To the extent that this is the result of the limits that producers place on them, both designers and producers are shirking their responsibilities.

When Modular Design is utilized, the products and systems so designed have a far better chance of producing safer, more secure, more user-friendly results. However, the production of safer, more secure and more user-friendly results, will still be the outcome of a lengthy developmental process. Many different options will be considered and tried, only to disappoint as each must function properly, not only on its own, but also in conjunction with other elements, components, products, or systems. A recurring problem may very well be that
something works well on its own, but not when placed in proximity or functionality with something else.

Good designers often can anticipate or spot technical problems, but not invariably. Sometimes there won’t seem to be “any good reason” why an option doesn’t work, until a lot of testing and thinking have occurred. Sometimes an option has to be foregone because of results “which just don’t make sense” regardless of how often fixes are tried. At some point, the only alternative is simply to try something else. Regardless of whether getting to that point has been easy or hard, quick to get to or slow in coming, something in the design and/or prototype has to be changed.

In tightly coupled designs, where everything depends on everything else, even a minor change may be a major undertaking. If one element or component has multiple interfaces and/or interactions with other elements or components, altering the source of a problem may lead to the need to alter every other element or component on a functional sequence. This could take considerable time, effort and expense. But scrapping the design and starting again could very well lead to similar costs in terms of time, effort and money. BUT if another design approach is not “readily apparent” then all of those involved must accept that such expenditures of development will continue.
AUDIT DESIGN EFFICACY

Is the design of the proposed or prototype product or system sufficiently robust, and have Action and Logic been adequately and properly separated, or do changes need to be made? The three key words in this question are “sufficiently,” “adequately,” and “properly.” What these words clearly imply are standards of performance that should be met. In other words, just some “sufficiency,” or a little “adequacy,” or occasional “propriety” will not do – the standards of safety, security and user-friendliness need to be fulsomely met.

In the case of tightly coupled products or systems, it is often (usually) difficult to discern either what the standards “should” be, or whether or not such standards have been applied. Action is often understood in terms of Logic, and/or Logic is understood in terms of Action. This way of looking at design is the result of believing that an “integrated approach” is what a complex product or system needs – since the functionality requires complexity, the only way to enable the elements and components to provide that functionality is to integrate their operations. This is a difficult challenge, but the very nature of the means by which to accomplish the technology’s goals requires that the design reflects the complexity of the tasks to be performed.

Applying these assumptions to increasingly sophisticated products and systems has resulted in designs that can no longer be fully understood or controlled. Advocates of Total Systems Control claim to be capable of delineating all of the parameters and functions, but mistakes and accidents keep happening. It’s time to re-think this problem. This could be considered just another case of a situation needing proper controls, but as with the technologies themselves, insurmountable problems are exactly what motivates innovations.

Perhaps it is NOT necessary to make a design as complicated as the tasks it is intended to facilitate! Statisticians are fond of pointing out that even systems with just a few simple elements can produce complex results because of the possibilities of mixing and matching. Perhaps product and system design could be based on the same insight. In hindsight, this is exactly the rationale for Modular Design. During the development of this approach however, the primary goals were control and reliability. But regardless of which intentions are prioritized, now that a design paradigm is available that addresses all of these challenges, it should be applied wherever concerns for complexity, control or reliability exist.

Once the modular approach is used for design, it is also available for design evaluation (Technology Assessment). The premise of Technology Assessment is that when initial design proposals or prototypes are presented for inspection, any design flaws or oversights can be rectified through re-design or retrofitting. So, whether producers and designers like it or not, their “solutions” are not “chiseled in stone,” but rather are part of an on-going process of
adjusting efforts to meet changing needs. At the same time though, producers and designers are themselves operating under certain constraints, so feasible possibilities are limited in number. Hence, the final configuration of any product or system will most suitably evolve out of *negotiation*.

How can technology designers and technology assessors ensure that their designs are robust? In other fields the answer to this question is through “over-building” – a safety factor in built into the product or system so that it can handle more than just its intended load without failure. Nevertheless, through cost-cutting efforts, these “margins for error” were successively reduced, leading to certain hydro-electric dam failures and other disasters. You can’t have it both ways – you either pay to build in the extra performance capacity, or you save money and jeopardize safety. [Those who claim these trade-offs are not necessary are either really stupid or just liars!]

Therefore, robustness and reliability are really “two sides of the same coin.” Achieving them will require, amongst other things, considerable amounts of testing of considerable numbers of alternatives. To anticipate issues from Section Two, this is where the participation of consumers is appropriate. If consumers describe “what they really want” and producers and designers explain “what they can offer,” then there is a basis for negotiation. It is very unlikely that any of these participants will get everything they want, but there is at least a possibility of negotiating a workable compromise.

Separating Action and Logic in design means distinguishing between the intended outcomes (functionality and performance), and the employed techniques (elements, components and configuration). So, as previously noted, various outcomes may derive from the use of a particular technique, AND a particular technique may support various outcomes. Action and Logic are not bound together so that one Action always implies one Logic, or one Logic always implies one Action. Instead, the designers can try a number of possibilities, and go with whatever works.

The key is to specify what will be included in (and excluded from) the definition of “what works.” Modular Design “works” by mandating specifications for the functional and performative aspects of products and systems. Every element, component, interface and interaction, must conform to the requirements in the design specifications – no exceptions. Modifications within a product or system for maintenance, repair, malfunction, or poor performance can be achieved through changes to elements, components, interfaces or interactions. Design changes themselves involve “going back to the drawing board.” In most cases the changes needed can be accomplished at the element, component, interface or interaction levels. The larger task of Technology Assessment is to indicate what, if any, aspects of the product’s functionality and/or performance, should be altered, and why.
PROVIDE SPARE CAPACITY

Besides ensuring robustness and the separation of Action and Logic, redundancy can also provide spare capacity so that an internal failure will be by-passed and functionality can continue. It is often possible for an element or a component to temporarily support a form of functionality different from that to which it is explicitly dedicated. In other cases, redundancy is achieved by simply replicating certain elements or components so that more load handling or additional flow channels are present.

If it is common practice for users or operators to run a product or system near or at its maximum limits, and if designers know this, it is both a good idea and common practice to design in spare capacity. This is more often done in products than in systems. Too often in system design, load capacity is specified for individual elements and components rather than connections and channels. The assumption is that if capacities are known and specified for each part of the system, then load-handling has been accounted for.

In tightly coupled designs however, connections can provide unintended channels, and these effects can aggregate producing overloads and/or interference. The fact that such things were not anticipated, planned for, or designed into a system (or product) does not prevent them from happening. If the timing of these connections > channels > overloads > interference sequences are erratic or otherwise idiosyncratic, there will often be no telling when a malfunction will occur or what particular chain of events caused it.

Producers and designers will often ignore the implications of this hypothetical chain of events, by rationalizing that it will probably happen so rarely that there is no need to design against it. When and if these circumstances do eventuate, the standard responses are to attribute the malfunction and/or accident to either “human error” or “an Act of God.”

With Modular Design it is possible to bring the technology back under control, which when practiced will mean much better safety and security. Within this paradigm, the challenge becomes developing a basis for deciding upon the kinds and levels of redundancy that are desirable. That raises the question of, whose version of “desirability” will be used to set the appropriate standards. Since there are stakeholders of this issue in all sectors of the society, negotiations and trade-offs will be necessary. Some of producers, designers, consumers, regulators and by-standers will all want a say in the decision – hence a procedure of accommodation must be developed.

Here again though, the behavior of users and operators also needs to be reviewed. Technology operators are often employed by companies whose work schedules are not mindful of equipment limitations. If contract requirements or performance requirements exceed the
equipment manufacturer’s operating instructions, too bad! Operators are told to “keep moving,” “push the equipment harder,” “not worry about the instruction manual says.” Eventually the results are industrial accidents, and the employees bear the brunt of the criticism.

Some users are also in the habit of “riding their tools to death!” Others either under-equip or over-equip themselves, both inappropriately. Under-equipped users will often tackle tasks that their tools just cannot handle, which could mean abrupt functionality failure AND perhaps personal endangerment. Over-equipped users may develop a sense of “great power” and use their tools in reckless ways, which could mean destruction AND perhaps personal endangerment. Users would be well-advised to realize that tools are not toys!

The biggest risks and the most widespread dangers however, are in situations wherein no excesses are being attempted, and no warnings are available. Complex extended systems, like electrical power grids, subway systems, power generating plants, telecommunications systems, large computer networks, and chemical processing plants, sewage processing plants, water purification facilities, to name just some obvious examples, all have experienced malfunctions, and safety and security breaches from time to time. After every big storm the electrical power goes out somewhere; telecommunication systems get hacked; computer networks crash; chemical plants catch fire or explode; raw sewage seeps into a recreational waters: and home owners have to rely on bottled water until the water purification plant gets fixed, just to give a few examples.

Many of these systems already have a degree of modularity in their designs. The Actions may be integrated (closely coupled), but the Logic is partially modularized. If a subway car breaks, or a computer is “fried,” or a telecommunication connection fails, that piece of equipment can be replaced rather than having to tear up and replace the entire system. Sub-sections of a power plant, power grid, or chemical plant can also be repaired or replaced without necessarily scrapping the whole system. But these changes are only possible if the problem are confined to a particular location or aspect of functionality. If the problem spreads beyond a limited number or type of components, the entire system is in jeopardy.

Introducing more modularity into products and systems which are not predominantly modular already, will be a challenge. BUT the safety and security gained should be well worth the time, effort and costs required. IF, that is, the primary concern of technology producers and users is the maximum feasible safety and security. For any producers OR consumers NOT desirous of “the maximum feasible safety and security,” the question they have to be asked is, “what then is your priority?” Since their priority, whatever else it may be, puts the rest of our lives at risk, they will have a lot to answer for. Technology Assessment is where those questions ban be asked, and those answers given.
FUNCTIONALITY FEEDBACK

Automobiles have feedback instruments to inform the driver about the condition of the vehicle. The speedometer gives unit of distance per unit of time (mph or kph); the fuel gage monitors how full of gasoline, ethanol, or diesel fuel the tank is; the collision-warning system alerts the driver if the vehicle is coming too close of another object (while backing up), or whether another object is coming too close to the vehicle (from anywhere in close proximity); etc.

Smart houses and buildings now have fire, flood, and unauthorized-entry alarms; appliances and equipment can also be remotely activated or de-activated, etc. Computer networks, telecommunication systems, and a growing number of other technologies all “report” on their on-going performance “in real time” (as they operate). What is beginning to happen however, is that some of the “artificial intelligence” in these feedback systems are trying to take some of the control out of human hands because, in the belief of designers, the system “knows better” than people do.1

Given what has been presented previously, and the “new agenda” for feedback, there are a number of problems and issues that need to be addressed. Firstly, even with the growing agenda of feedback, what is NOT being reported on, to either users or operators, are the cascading sequences of dangerous interactions that could lead to malfunctions and/or accidents. During these events, some feedback readings are often presented, BUT they are usually misinformed and misleading – they DON’T indicate what the “real problem” is, and they to point to factors which are irrelevant or of minor importance.

Secondly, some of the relevant feedback is beginning to be used to take control of operations out of human hands and turn it over to computers. If a navigation system in an automobile and the driver struggle to control the car, neither the person’s agenda nor the computer’s will necessarily dominate – so the car’s performance might become erratic, and a very real possibility exists that harm to

the driver and damage to the vehicle could occur simultaneously. To revise an old adage, computers “should be on tap, not on top!”

What the appropriate role for feedback should be, is an informant of the functionality and performance of the technology being used or operated. This means that any impairment in functionality should be reported immediately, thoroughly, and in a manner understandable to the user or operator. Those same users or operators should also have the training to be able to appropriately respond to the feedback.

Modular Design would first of all, make the diagnosis of impaired functionality much easier - it could be located and categorized, so that a user or operator would understand what the problem was, and where the problem was. A suitably sophisticated diagnostic feedback system could also review most effective solutions used for these types of problems on previous occasions. This latter option would probably only be appropriate for larger systems in most cases, but whether to make it available or not might depend on the nature of the risk posed by the impaired functionality.

Impaired functionality can be described in terms of various levels of seriousness. If the feedback mechanism were to report an impairment of a minor nature, or with an aspect of functionality not then being used, perhaps operations could continue and the problem could be addressed at a later time. If however, that impairment could lead to other contingent impairment, then operations should cease and repairs arranged immediately. Either the feedback mechanism should indicate the seriousness of the impairment situation, or users and operators should be trained sufficiently to recognize the urgency of the feedback report.

When serious impaired functionality is reported by feedback, there should also be procedures user or operators can apply to deal with the immediate situation. Perhaps there is a proper sequence to follow when disengaging functions. Perhaps there are things to check on, and report on during repairs. Perhaps there are initial steps that a user or operator can take any damage done during impairment. Any of these options that are feasible should be designed in to begin with, OR made part of a retro-fit subsequently.
WARNING FEEDBACK

Can feedback within products and systems be designed to issue warnings when functional parameters reach critical thresholds? Yes it can – in fact, there are already some examples operating. When the fuel gage gets too low, a warning light on the dashboard is illuminated. What is needed is a diverse feedback network that can alert users and operators whenever ANY functional parameter is approaching a critical threshold. The advantage of Modular Design is that such a feedback arrangement within this kind of product configuration, is much easier to design, AND can be made very reliable in its operation.

By the time that functionality failures or overloads actually become obvious to an operator or user, it is often too late to take corrective action that will enable the technology to continue performing. The advantage with the design of the fuel gage warning arrangement, is that it does alert the operator or user early enough that there is usually time to re-fuel. That same concept of feedback should be designed into all product and system functions.

Many industrial accidents, including those that cost million$ in property damage, and/or results in many injuries or deaths, occur because there is no warning of impending overloads or failures, and the product or system continues to function until it “crashes.” Producers often “pretend” that these incidents are “Acts of God.” But if there are no warnings about problems that are developing, then this lack of information is a form of negligence.

As a result of overloads, products or systems may behave (or misbehave) in a variety of ways, depending on the type of overload (mechanical, electrical, or informational), the level of overload (just a little, quite a bit, or much too much), the nature of the product or system being overloaded, and the response of the product or system to overload (a slight blip, continued but labored functioning, or abrupt stalling). The implications of any of these outcomes in turn, may involve safety of users, operators, and/or by-standers; “survival” (or lack thereof) of the product or system; and security of the on-going operations in which the product or system is participating.

Although impending failures may occur as a result of overloads, other causes are also possible. Lack of a proper maintenance schedule is a notorious cause. One reason for such poor maintenance may be the costs of the inspection, new parts, and installation fees. Tightly coupled designs are usually complex enough that only a designated service person is both authorized and qualified to perform maintenance work. In addition, if new elements or components are needed to replace broken or worn out ones, they may not be in stock and hence a waiting period is required for these new parts to be ordered, shipped, received, and the client contacted. If owners, operators, or users are impatient, they may elect to carry on operating the product or system until everything is ready for the maintenance services.
Improper operating procedures are another cause of impending failures. In the case of impending mechanical failures, the product or system may actually “lurch” in its performance in response to improper use. Its running speed may either speed up, or slow down, depending on how the product or system is designed. The user or operator may not “realize” that some limit has been exceeded, and may simply ignore the “tell-tale signs” that some difficulty has been encountered by the product or system. If the user or operator had “throttled back” when the initial signs of trouble were encountered, perhaps no harm would have been done, to the equipment, persons or property. If the use persists however, failure is all but inevitable. These are the kinds of circumstances where warning feedback could benefit producers and designers, as well as users and operators.

Yet another source of impending failures could have nothing to do directly with either the equipment or the users/operators. External impacts are very common, and some of them can be disrupting and/or damaging. The working environment in which a product is used may not be particularly safe or secure. Something could fall on the product, or the operator. Thereupon the product, if still functioning, could run out of control, with any number of consequences. OR the product could be crushed or damaged in some way (bent, broken, be unable to turn off, be unable to turn on, etc.). A power surge could “fry” the product; a flood could short-circuit the product.

How could warning feedback be helpful in these types of cases? What the warning feedback mechanism needs to have designed into it for these occasions, is an automatic and instant shut-down capability that is engaged when the nature of the impending failure is catastrophic (from the product’s or system’s perspective). This would be tricky design challenge, but in view of the consequences of for users/operators, the product, and the surrounding environment, this would probably still be the safest procedure to rely upon. The precise timing and sequence of such a procedure would have to be based on considerable testing experience.

When products or systems do not have any, or adequate warning feedback built in, they should be either extensively retro-fitted to include such feedback, or the equipment should be entirely replaced by new models that have modular configuration AND warning feedback as part of their design. To any producers or owners for whom this recommendation comes as a surprise or shock, the question to be asked is, “why do your costs and convenience take precedence over the safety and security of users, operators, or the general public?” Every accident that has equipment implications involved in it, is a cost that producers or owners try “externalize” to the remainder of society. Occasionally law suits or settlements are won, but the majority of accidents caused by poorly designed equipment are just absorbed by the wider society. It time that producers adopted a design policy that accepts their civic responsibility to be good citizens as well as successful business people. The Design Meta-Rules can start the process, and Technology Assessment will demonstrate the efficacy of that approach.
Once the design, testing, prototyping and market strategizing are completed, it is time to “roll out” the product or system to the consumers, users, operators and commentators. Some of those commentators will be Technology Assessors. At present Technology Assessment is only practiced informally except in a few special cases (if the technology’s production or use are heavily regulated, both the prototype and the final product or system may very well need prior approval AND later receive impact evaluation). Just as anticipated Technology Assessment can be one of the considerations in Design, similarly Re-design can be one of the considerations in Technology Assessment.

A good way to begin deployment is to recruit the initial users as part of the testing process. Their payment for the product can be their willingness to report back on its functionality, safety and user-friendliness. Users often prioritize different aspects of product performance than to designers or producers. Too many “bells and whistles” may interfere with the user’s concentration, or may confuse regarding the required sequence of operational instructions. In other cases, problems may only develop after a new product has been in use for a certain length of time. Producers and marketers are usually anxious to get the product out and widely distributed as soon as possible, but this assumes that only minor problems, easily cured or ignored, will arise. Experience often belies this assumption.

Technology Assessment attempts to anticipate disadvantages and detriments based on the technological parameters of the product in question, AND the types of social and environmental impacts that are likely to occur with this kind of product. Based on the histories of previous products, we now have extensive examples of multiple versions of unwanted effects, emergent problems, unanticipated impacts, and dysfunctional synergies (interactions between otherwise acceptable technologies that together produce harmful results – for instance, automobiles and mobile phones). Assessment identifies the problem and proposes retrofits to correct those problems.

Retrofits will be far more readily dealt with in Modular Design rather than integrated design. For this reason, Modular Design should always be the premise of corrective actions. Through reverse engineering, successful instances of design can be catalogued for further use. There are often a variety of ways that solutions can be applied to enable retrofitting. Furthermore, a product’s “clean bill of health” is usually only temporary – ongoing use may disclose new problems necessitating new retrofits.

Producers and distributors of products and systems are fond of claiming that “the customer is king.” So if all or some of the customers have concerns about an innovation, those who are offering this innovation in the market should take heed, if their rhetoric is going to be believed. Assessment on behalf of these customers is a way of getting the message to producers. When the innovation implies significant detriments, it should be re-designed or retrofitted. No excuses – more thoughtful design is needed.
THE DEPLOYMENT PROCESS

Once the various aspects of Design have been performed (adequately or not), the Technology Deployment Process begins. What occurs is an attempt for target a market for the technology (product or system), by advertising and using other forms of promotion, arranging and accessing distribution channels, getting endorsements, conducting consumer focus groups and user surveys, and responding to comments and suggestions from Analysts and Interest Groups. Each of the responses to the “new or improved” product or system, will constitute some form or other of an assessment – is the price reasonable, are the features agreeable, is the performance acceptable, is the impact beneficial, does the product or system properly solve the problem it is supposed to address?

Even highly successful producers will find some of their new offerings are flops – either the consumers think the price is too high, or that a competitor’s choice is in some way superior, or that the “solution” is no real solution at all, or that some notable person or group delivers substantial criticism, or concerns are expressed about environmental or social impacts, or regulators raise non-compliance issues.

On the other hand, many producers do successfully navigate their way through the “marketing maze” and go on to achieve considerable sales. As the product or system goes into use, further results (immediate) and consequences (longer-term) are experienced. Mobile phones are very popular, but their use while driving automobiles leads to traffic accidents and deaths. Bottled water is a great convenience, but the discarded plastic containers create considerable disposal challenges. Some new medications provide needed treatment and relief, but their side-effects can be troublesome, even lethal.

Four “new technologies” in particular are now forecast to precipitate “revolutionary” changes over the course of the 21st century. Info (computers and telecommunications), Bio (genetic medicine and engineering), Cogno (brain science and artificial intelligence), and Nano (molecular manufacturing and pervasive automation); each seems poised to produce wide-ranging and deep-seated changes. In addition, the designers of these technologies are cooperating and coordinating their efforts so that they all complement one another in terms of both development AND impacts. Each of these technologies therefore poses considerable risks to both society and the environment. Such prospects as massive invasion of privacy, human cloning, electronic implants to the brain, and massive unemployment, are all on the drawing boards!

If we just, by and large, sit back and wait for these things to happen, considerable amounts of harm to people and damage to the environment will occur. Furthermore, the more widespread the effects, the longer it will take to rectify the problems, and the higher the costs will be. But without systematic investigation of new products and systems, we will often fail to anticipate such problems, or be sufficiently informed to develop solutions. This is where Technology Assessment “comes in.” If we adopt these “new technologies” in ignorance, we will live in increasing frustration and regret!
What Technology Assessment involves is applying a check-list of requirements and concerns to every proposed innovation. The check-list would cover aspects of both Design and Deployment. In a general sense, the same kinds of considerations would apply to all prospective innovations. Furthermore, the check-list would be readily available, so both consumers and producers could use it to plan any “technology assessment strategies” they thought were suitable. Since Deployment follows Design, the Deployment aspects would come in the second half of the check-list.

### DEPLOYMENT RULES TO IMPLEMENT TECHNOLOGY ASSESSMENT

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Implications</th>
<th>Retrofits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track technological impacts regarding functionality and performance</td>
<td>Impacts include costs of user training, prospects of malfunction, etc.</td>
<td>Correct malfunctions and undesirable performance through re-design</td>
</tr>
<tr>
<td>Track economic impacts regarding diffusion and productivity</td>
<td>Impacts include cost of the technology, likely obsolescence of other technology, repairs, etc.</td>
<td>Reconfigure technological alignments to enhance performance &amp; productivity</td>
</tr>
<tr>
<td>Track social impacts regarding perceived &amp; unperceived benefits &amp; detriments</td>
<td>Social impacts include disruption, demand overload, downstream consequences, etc.</td>
<td>Redesign or recall the technology to increase benefits &amp; decrease detriments</td>
</tr>
<tr>
<td>Track environmental impacts regarding damage, pollution &amp; disposal</td>
<td>Impacts may be the result of functioning, by-products or eventual decommissioning</td>
<td>Redesign, reconfigure or recall the technology to eliminate environmental detriments</td>
</tr>
<tr>
<td>Forecast the results of prolonged usage on the various types of impacts</td>
<td>Anticipated future impacts may be positive or negative, but both need attention</td>
<td>Redesign, reconfigure or recall technology in light of likely future emerging impacts</td>
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All of the considerations in the boxes relate to the Deployment Process. The basic premise is that if Deployment is done in a way mindful of the necessity for Technology Assessment, the results will be less disruptive to everyone involved, and more likely to provide better products and systems to users and operators. Whatever problems may emerge later after extended use, can also contribute to Assessment experience so that practitioners will begin to recognize “tell-tale signs” of impending detriments before they arise, thereby providing a basis for recommendations for retrofitting that can avoid negative impacts rather than simply reacting to them.

The remainder of Part Two will “unpack” each of the above boxes to provide a brief overview of the objectives and processes involved. When a Technology Assessment recommends a retrofit or redesign, the larger message is that looming detriments should be avoided, and emerging detriments should be rectified. The marketplace for innovations should NOT be treated as a “wild frontier” where anything and everything is allowed in the name of inevitable change.\(^1\) Only beneficial change is worthwhile.

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\(^1\) John Macdonald, CALLING A HALT TO MINDLESS CHANGE, American Management Association, New York, 1998
Chapter Five
IMPACTS

However the immediate functionality of an innovation (product or system) addresses the “problem” that it was produced to solve, it will have additional impacts, on the environment, other technologies, customers, other people, companies, governments, and various interest groups. There may be more impacts, some not even initially recognized. These impacts are what can be termed product and producer “externalities” – they are often “outside” the concerns of the people and things that caused them. If, beyond the occasional criticism, there is no “come-back” to producers, their attitude can often be summarized by “too bad!” or “get used to it!” Why should they do anything more if there is no compelling reason? And very often they do nothing more.

If revenues from sales confirm the decision to produce and market, producers focus on meeting and increasing demand. This is the power of the marketplace. If there are some impact concerns, but most customers are simply passive recipients, “too bad” and “get used to it” may continue indefinitely. By the time serious problems eventually emerge, correcting any detriments may be very disruptive, time-consuming and expensive (for those impacted).

All of this can be explained by the widespread willingness to “give them the benefit of the doubt.” A favorite slogan for advertising new things is, “try it, you’ll like it!” That was the rationale when DDT was marketed as a pesticide, or when Thalidomide was marketed as a sedative for pregnant women. When it comes to new technologies, experience by now should have taught us that the best rule to follow is “the extent of assessment should (always) reflect the potential risk involved.” People’s health and safety, and the prospect of environmental harm (avoiding pollution and resource depletion) should take priority over profitability.

We therefore need a check-list of issues to raise when society encounters innovations being deployed. What should we be looking for? Are there categories of questions that can guide the process of assessing a technology proposal or prototype? What about the argument that since “we can’t see the future” this whole effort is futile anyway? In beginning the Assessment process, it would be wise to keep the following advice in mind: Producers can, have and will go to extreme lengths to discredit any and all efforts to halt their march towards profitability: for years tobacco companies denied the health risks of smoking, automobile manufacturers denied the safety risks of many cars, chemical companies denied the environmental risks of pesticides, and the financial services industry denied the risks of most investments. Giving them the benefit of the doubt just encourages them to continue laying their risks on the rest of us.

Every detriment that we can forestall or rectify is another good reason for Technology Assessment. With some of the things on some of the drawing boards, we should be careful.
TECHNOLOGICAL IMPACTS

This particular module is concerned with the impacts a product or system has on other products or systems directly, and then on society or the environment. When asphalt replaced concrete in road construction, the “impact” was: (1) more miles (or kilometers) of roads, (2) more automobiles to operate on those roads, (3) more people travelling on more roads in more cars, and (4) more traffic accidents happening to the more people in more cars travelling on more roads.

So, according to one wag, more asphalt causes more traffic accidents. NO – this is not “cause and effect,” BUT without more roads and more cars there would not have been nearly as many traffic accidents! In this type of analysis, we are not “blaming” asphalt for more roads, more cars, more drivers, or more accidents – asphalt is not a “moral agent” with rights and responsibilities – however its application can lead to a sequence of events with profound consequences.

When you think about it this way, there are a multitude of things around us that could each be the start of another sequence of far-reaching consequences. Mobile phones can provide 24/365 communication; whereby a person can stay connected with their “friends” every waking minute; whereby privacy can be jeopardized, whereby a person can do internet, e-mail and online banking, etc. Do mobile phones “cause” traffic accidents when drivers pay more attention to communicating than to control of the vehicle? Is the phone responsible? Is the manufacturer, or service provider, or phone retailer responsible? They are all people, which means moral agents!

Some people actually do “blame” the technology. Others blame the users. Others still blame the producers, distributors, regulators, or whomever. But there is a “bigger” issue here than simply searching for someone or something to blame. (a) To the extent that technology exists and is used, it invariably has impacts. (b) The quantity and quality of the impacts are NOT “natural” or “inevitable” – if changes had been made strategically along the sequence of consequences, the impacts could have been radically different. Automobiles and streetcars formerly had ‘running boards” along the sides of the vehicles – people who stood on these running boards frequently fell off, injuring or killing themselves. Laws could not successfully stop this practice, so running boards were DESIGNED OUT of these vehicles. It can happen!

Every feature, function, and failure displayed by a technology, is there because of design intention or negligence. Technologies are NOT natural – they are contrivances – people “invent” sets of tools and techniques to accomplish objectives – sometimes they are careless, or thoughtless, or impatient, or greedy, or megalomaniacs, etc. But whatever the purpose, no technology deserves “the benefit of the doubt” and all should be held evaluated.
To remind the reader, we are reviewing the effect of one technology upon another technology; other kinds of impacts will be considered in due course. Since all technologies (so far) are unfeeling (insensate), what does it matter which technologies effect which other technologies? Let us consider the roads > vehicles situation again. Let’s consider a lucky (and admittedly rare) day when there are no deaths or even accidents on a main thoroughfare. More vehicles still mean more traffic jams, more wasted time, more lateness, more exasperation and distress, more gasoline expense, more appointments and opportunities missed. And that’s just two technologies (paving and vehicles).

The “burden of technology” is that between the intended effects (functionality) and the unintended effects (contingency), the myth of a “technologically care-free existence” is about as likely as “an honest used-car salesman.” In an urbanized environment, most of the natural risks have been replaced by socially-created risks (i.e. technology).

So, technology performs functions for us, but in the process it interacts with other technologies, with the result that the combined effects and impacts will be more, usually much more than the sum of the parts. I want the convenience of a computer, but I don’t want to have to learn to use every software application necessary to get the results I want. And I certainly don’t want to have to relearn the software application with every upgrade that gets released! Before the reader says “That’s just the way it is!”- remember that it DOESN’T have to be designed this way!

Where a Technology Assessment should begin is with any and all functionality and performance impacts between technologies. Do any of these cause malfunctions or failures in the effected technologies? Do any of them cause inordinate inconvenience, delays, confusion or expense? Are these impacts really necessary or unavoidable, or have such impacts simply been ignored or overlooked? Are there feasible design alternatives that would eliminate unnecessary impacts between technologies? If so, these alternatives should be recommended.

This is when the resistance will start (if it hasn’t already)! Producers and designers may express it many different ways, but they can all be summarized with one familiar phrase – “leave well enough alone.” They are pretending to welcome Technology Assessment as part of their public relations ploy, BUT they do not welcome actual change suggestions. A little adverse publicity via the assessment process may be needed to get producers in the right frame of mind for redesign or retrofitting. This is why having the Technology Assessment Process sponsored by government BUT in an arm's length relationship with government, assures sufficient support to get the job done, but eliminates the likelihood of any untoward pressure tactics.

Since all technologies could be designed differently in some respects, their proposed configurations and impacts are the direct result of prioritizing some preferences over others. But since the impacts will affect the wider society, these choices should be justified. Technology Assessment is the process to question these choices, and propose changes.
ECONOMIC IMPACTS

To have economic impact, products and systems must be acquired and used. Acquisition may occur by way of buying, renting or freely accessing, but whichever it is, the products or systems must come into use (diffusion) before it will have an effect on productivity. Whichever aspect of life the advertisements promise to improve (make more productive in an appropriate way), the technology will only make such a contribution if its functionality can be harnessed by the users. But this often turns out to be a questionable premise.

Information processing technology will enable more processing of information. But to what extent will more information enhance productivity? The answer is that it depends on the knowledge possessed or accessible by the user. Knowledge consists of concepts available to process information and guide action. Without strategic knowledge of the context and capability for information use, information processing technology is just another business status perk.

However, this limitation does not sit well with a number of business analysts and consultants. They prefer superficial analysis rather than deep knowledge because it requires less thinking! While searching for an opportunity to fit this inclination, they became acquainted with a software package designed to handle the plethora of data from astronomy sightings. And so began the rise of BIG DATA. What this capability of information processing enabled was a significant number of correlations (statistically coincidental occurrences) WITHOUT any concern for cause and effect – the coincidence of sun-spots and economic cycles is an old example.

There are now rumblings that this “tool” will be used to analyze population statistics, and to formulate public policy on the basis of the “findings” extracted from this data. BIG DATA is already being used to plot consumer profiles so that advertising can be targeted based on the coincidences between buying patterns and psychological idiosyncrasies. With the trend for governments to push responsibilities back down to consumers, public policy analysts will likely use BIG DATA to search for programs that do not coincide with currently supported issues, so that funding can be cut back without much “blow-back.” The hardships created will be ignored.

Some technologies do indeed result in more productivity. The benefits however, are not necessarily widely shared, although the detriments more often are (widely shared). Middle Class and Lower Class incomes have declined as a proportion of GNP, whereas Upper Class incomes have increased as a proportion of GNP – there are “more toys to go around” but the majority of the benefits are being “hogged” at the top, while everyone else gets by with less!

1 William Sheridan, HOW TO THINK LIKE A KNOWLEDGE WORKER, UNPAN website, UN Headquarters, New York
What these latter example speak to, is that “economic productivity” has two equally important aspects, namely production and distribution. If more is widely produced, but less is widely distributed, the social rationale for “more” is undermined, just as surely as if more is produced and distributed, but the main impact of the wider distribution is detrimental. However, only the distribution of technologically associated benefits and detriments is covered by Technology Assessment.

Are productive technologies being widely diffused, or are prices, licensing agreements, or training restrictions slowing such adoption? Are the technologies that are being diffused notable boosters of productivity, or just opportunities to boost producer coffers? Do the products and systems offered actually deal with economic problems they repute to address, or merely keeps consumers and operators on continuously running “upgrade treadmill”? Questions like this are the opportunity to include users and operators as participants in the Assessment process. Are users and operators getting the benefits they want and were promised, and what do they think of the detriments, if any, that accompany the products and systems they use? The best way to get answers to these questions is to invite a representative sample of operators and users to actually work with the Assessment team.

Both producers and consumers should be getting (sharing) economic benefits and avoiding economic detriments of products and systems. If the long-term economic effects of technology use are to polarize individuals and groups into haves and have-nots, then any occasional benefits are more than offset by accumulating detriments. Can Technology Assessment effectively deal with this kind and this scale of results? In all likelihood, the economic impacts that Technology Assessment can handle will be confined to case studies of individual technologies, their design, deployment and results. Therefore, economic impact questions must be directed towards particular instances.

However, exaggerated productivity claims, and understated acknowledgement of detriments, can be challenged. Products and system should live up the hype used to promote them, or producers should re-state their promotions to reflect product or system limits as well as their capacities. What often happens is that by the time the few benefits are realized, the concurrent detriments have offset much of the “social good” that was generally seen as the larger motive for “technological progress.” Perhaps a more agreeable arrangement might be community control of the technology using enterprises. Another option would be “Open Book Management” wherein both company control and benefits would be shared more equitably.

The assumption behind the use of technology is that it builds “wealth.” But for wealth to be worthwhile, it must be shared equitably enough that all participants feel they are getting more benefits than detriments from the process. With users and operators participating in a Technology Assessment, these types of broad concerns can be raised, and “techniques” discussed on how to solve this kind of problem.
SOCIAL IMPACTS

The existence, extent, and evaluation of Social Impacts introduces a “complication” that is less of a concern regarding Technological and Economic Impacts. Firstly, not everyone perceives the presence of certain Social Impacts. Sometimes this is just a question of oversight or taking a different perspective. However, in some cases the contention that certain Social Impacts do, or do not exist, is fundamentally and adamantly denied. These deniers may consider the contention of such impacts as either a personal or a social criticism that they regard as unjust, and therefore unacceptable. Or there may be other reasons – but whatever the motivation, some people will just “not sit still” for the contention of Social Impacts!

The majority of people will however, concede the occurrence of Social Impacts in a general sense. There is still the question though of whether or not a particular Social Impact has occurred or is occurring at a particular location during a specific time-period. That is covers complication Number One. Complication Number Two is a possible disagreement as to whether a particular impact incident or type, is a benefit or a detriment.

Regarding the first complication, some people do not acknowledge that certain forms of discrimination even exist. In situations where others regard the presence or use of technologies as contributing either to more or less discrimination, deniers will refuse to even discuss the possibility. These people are not usually in the majority, but they do appear whenever an invitation for public participation is proclaimed.

As to the second complication, it is far more widespread. If public transit construction is “modernizing” a city, it will also be disrupting certain neighborhoods. Those looking forward to faster, more efficient public transit will see the forthcoming changes as benefits. Those who want to preserve their traditional neighborhood will see the forthcoming changes as detriments. The lesson here is that a technologically induced impact can be both a benefit AND a detriment depending on how it actually impacts recipients. One size does not fit all.

In these circumstances, it is essential to begin by surveying the attitudes about prospective or existing social impacts. Some people may not oppose the impact per se, but rather the way it has been “laid on them.” If they were not consulted, or their views were dismissed, they may be fierce in their opposition. Others will oppose the particular goal, or all goals of this type, regardless of the arguments that are made.

Once public opinion on a social impact of technology has been “mapped,” it is then useful to enquire into the motivation for the views expressed. Some people have very unrealistic expectation, either positive or negative, about technologies. What may be happening is that a particular technological issue is just a “test case” for a more fundamental concern. Perhaps
other ways of addressing the “fundamental concern” could be agreed to, and this particular case would no longer be a Social Impact roadblock.

The same strategy can apply to those concerned with Social Impact benefits. Perhaps a particular proposal or prototype has been “over-sold” as a “solution to all our problems.” Closer examination may reveal that whatever benefits a particular technology can bring, it cannot be “all things to all people,” and it may include significant detriments as well as benefits.

Since there are no “objective” measures of benefits or detriments that will be universally accepted, it would be wise to catalogue the “reasons” behind the support or rejection of technological proposals. A comparative analysis could then be performed to determine how many people held each of the opinions expressed, and whether or not there were any points on which there was wider agreement. In all likelihood there will be some common ground on issues, even among opponents. It is this common ground that will eventually become the basis for negotiating trade-offs between the opposing issues and groups, so that those involved make some gains but also accept some compromises. Those agreements and compromises can then be the foundation for Technology Assessment recommendations to modify the technology in terms of the occurrence of the Social Impacts of benefits and detriments.

Are there any “generalized social impacts” that most people would agree are detrimental rather than beneficial? One that springs to mind, and that both Sociologists and Anthropologists concur on, is the prospect of disruption. An eminent economist, Schumpeter, was a great fan of disruption because he believed it often heralded innovations – new ways of doing things would often disrupt habitual ways of doing things, and since he was an advocate of “new things,” he welcomed disruption as a positive sign of change. Nevertheless, most people do NOT welcome such disruptions unless they are convinced that accommodating the change is worth the effort.

What most people “have” is an implicit cost-benefit technique that they apply to the various “requirements” that they encounter. IF they decide that “the change is worth the effort” they can handle disruption in ways that would have made Schumpeter proud! BUT, if the proposed or imposed change is judged to NOT be worth the effort, the change will be resisted and the disruption will be resented. AND, in a free society, everyone is entitled to their own opinion!

Another social impact for which there is general agreement about its detrimental effects, is the loss of benefits that a person previously had. More than the disappointment of not gaining more benefits, losing previous benefits is both regretted and resented. If for whatever reason, technologies contribute to the loss of previous benefits, their entire impact is often condemned. Whether this kind of impact was intentional or not, if the agent of dispossession is a technology, then “technology” itself can get a bad name. Designers and producers, wake up; always watch for technology-induced benefit losses and rectify them (avoid more enemies)!
ENVIRONMENTAL IMPACTS

Air pollution during the coal-fired Industrial Revolution in Europe produced acid rain, contaminated waterways, and caused serious human respiratory problems. Later these same effects occurred in North America and in East Asia, and for the same reasons. Thankfully, more recent efforts have begun to reduce air pollution.

DDT was a chemical pesticide brought into widespread use after World War Two. Eventually research evidence emerged indicating that chemical residues from DDT accumulated in fat tissues all the way up the food chain, causing serious biological malfunctions. In this case as well, other pesticides with less or no such effects, eventually replaced DDT use.

In a number of deep sea trenches that are containers of toxic waste, some chemical, some nuclear, that are slowly being buffeted by various actions (currents, pressure, internal corrosion). This is “the elephant in the sea” of pollution issues, but it is practically never acknowledged or addressed.

Therefore, regarding pollution, in some respects humanity is doing better than previously, and in some respects we are not doing anything. And as more and more artificial materials are developed and used, it becomes more and more urgent to monitor and control environmental impacts at tightly as possible.

Methods to monitor and track environmental impacts has been very well developed. The problem is not “how” to do it, but whether to do it! New York City is still towing and dumping barges of garbage in the Atlantic Ocean, and many other cities use the same kind of disposal method. All human waste and garbage collection-disposal systems should be completely closed-loop systems, with all inputs completely recycled. Until this is achieved, humanity is still in trouble when it comes to environmental impacts.

Technologies contribute to the problem in two ways: (1) they produce by-products and wastes as a result of operations; and (2) when they are worn out or discarded, they become “junk” themselves. Hydrocarbon-fueled automobiles give off exhaust which is often polluting. Old tires are discarded, sometimes buried, sometimes burned. Old batteries often corrode and spill acid on the ground. Oil pans and radiators often leak, and can also contaminate the ground. When a vehicle has reached the end of its working life it may be left to rust wherever there is space for it. Any experienced driver can give more examples!

Technology Assessment can estimate the likely “pollution and contamination” potential of a technology by reviewing other technologies with similar functionality, configuration and performance parameters. Technologies that “do the same kinds of things” are likely to exhibit the same kinds of pollution potential. Technologies “constructed of the same kinds of materials” are likely to present the
same kinds of disposal problems. Technologies that require certain types of inputs are likely to have the same kinds of outputs.

An ideal “solution” to mitigating environmental impacts would be one that complemented another type of impact rectification. Disposal of old tires has been a troublesome issue. Then an innovative recycling idea was developed. The tires can be shredded and the material used as an aggregate in asphalt. This produces a more weather-resistant product, reduces the requirement for other components, and eliminates the need for disposal altogether.

Environmental impacts are also an opportunity to try design alternatives that eliminate or reduce pollution or damage. Paper-recycling has already pioneered in this area. The processing and re-use of previously utilized paper required different techniques than the paper manufactured directly from wood pulp or rags. Now paper-recycling is a major industry, and using re-cycled paper in publishing is regarded as a show of good faith by environmentalists.

Many art works and curios are also created from recycled household items found in dumps or at land-fill sites. Burning organic-based garbage to generate electricity, is also on the rise. Plastics and glass from household garbage can also be recycled, and frequently is using re-cycle bins at individual homes or multi-unit building. More should be invested by governments in R&D to develop ways to expand and support recycling.

Discovering and rectifying detrimental Environmental Impacts will turn out to be one of the biggest challenges for Technology Assessment. As Global Climate Change demonstrates, effective measures can only be implemented if designed on an eco-system basis. The Great Lakes Basin is a good example: jurisdiction over the area is shared between two national governments and a larger number of provincial and state governments. Unless consistent measures were agreed upon and adopted by ALL of the governments involved, it won’t have been possible to limit pollution and other sources of environmental degradation. Since much of that pollution and other forms of degradation originated with technology use, intra-national and inter-national negotiations and enforcement are necessary.

What Technology Assessment can do is to alert the wider society to the dangers of Environmental Impacts. Experience with DDT shows that was appears to be minor contaminations, can, over time, accumulate to a point where they exceed a critical threshold, beyond which serious harm can start to occur. This is the insidious “slippery slope” where what begins as minor infractions suddenly turns into an environmental crisis. The reason this can happen with Environmental Impacts, and the other types of impacts as well, is that the dynamics within the technological-economic-social-environmental system are non-linear rather than linear. Non-linear changes can go from slow and steady to wild acceleration when they reach critical thresholds. We need to recognize the kind of phenomena we are dealing with, if we want to minimize detrimental impacts in these circumstances.

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FUTURE IMPACTS

Part of the challenge with introducing innovations into society, is that benefits may be obvious from the beginning, whereas detriments may not emerge until considerable future use. One particularly ironic instance of this pattern is what Marshall McLuhan called “The Reversal Effect.” Many innovations are beneficial within certain confines – if they are used appropriately, as intended, few if any detriments will arise. However, users become over-enthusiastic, and begin to over-use an innovation. Once use-patterns go beyond the intended purpose, detriments begin to emerge, and if this over-use persists, much of the good from the original benefits is reversed by the accumulating detriments. (When will we ever learn that “enough is enough?”)

In many other cases though, even intended use can lead to detriments. Vehicles travelling on roads, only becomes a problem when too many vehicles are on the same road at the same time. But traffic jams may not emerge until considerable time after the road is initially built and put into use. Load factors (magnitude of use) is usually a problem in all systems, if “traffic” keeps increasing with time. One attempted solution is to schedule use with a timetable – some uses occur at one time of day, other uses occur at other times of day. But timetables can also become overloaded!

The occurrence of overloads can often take considerable time to develop. At first there is just the addition of new capacity or capability to the technological inventory, and those wanting to utilize the products or systems are pleased with the opportunity to begin use. But if utilization rates keep growing, eventually even a large performance addition will be used to its full extent. If demand grows beyond that, there will be overloads (“traffic jams”), and demands for even more expansion. Concurrently, other technologies that operate in any way complementary to the products or systems in question, may also find increases in use, and eventually overloads. More roads, mean more cars, and more cars means more tire, gasoline, brakes, mufflers, accidents, repairs, insurance, etc. Eventually we are devoting too much money and space to road transportation technologies, and we have to start encouraging people to use public transit more!

The result of automobile use was to change the entire pattern of city development, as well as shopping habits, youth socialization, dating behavior, house design, money lending, industrial manufacturing, and labor unions. Many of these patterns are now being criticized as unintended and undesirable. Be that as it may, practically none of these trends were foreseen when the automobile began to be mass produced. Genetic Engineering, or Artificial Intelligence, or Big Data, or Nanotechnology could have even wider and more profound effects, if they are simply developed and deployed without proper Technology Assessment.
In almost every case, technologies are intended to have persistent rather than temporary impact. As time goes on, such technologies will achieve wider and wider deployment, interact with the “people-environment-other technologies system,” and have both intended and unintended effects (impacts). Since this extended functioning and interacting, produces complex and non-linear results, the exact outcomes and consequences can only be approximately forecast and planned for. Nevertheless, in a general sense, a combination of past cases and knowledge about technological parameters, can alert us to categories of challenges and types of solutions.

There have been a large number of case studies of the possible impacts of the four new technologies (Info, Bio, Cogno and Nano) that forecast such “categories of challenges.”¹ In each case, the prospect of widespread use are extremely disruptive and risky – in conjunction they could cause massive psychological disorientation and serious social breakdown. It would be both profoundly irresponsible and profoundly foolish to deploy all or any of these technologies unless and until they are given thorough Technology Assessment. Those who are advocating immediate use (as soon as innovations are developed), are seeking just two things: (1) money from the sale of products and systems, and/or (2) fame, prestige, status (public recognition for discovery [scientific & technical prizes]), or political & social adulation [the new poster-children of social media]). Their desire to “rush to roll-out” clearly confirms an implicit or explicit attitude of “the consequences be damned.”

It is the responsibility of Technology Assessment to resist pressures for “a quick report” or “producer propaganda.” As John Macdonald to wisely pointed out, the only kind of change that is worthwhile is that which provides clear and consistent improvement throughout all aspects of its impact.² If and when Technology Assessment finds analogies, indicators or trends that imply that a particular product or system will produce or experience impacts, results or consequences that are too risky or widely unacceptable, serious suggestions for re-design and/or retro-fitting are appropriate and a responsibility. Furthermore, there suggestions should NOT simply be buried in a report that will be shelved and forgotten. The BEST guarantee that this will not happen (ignoring TA suggestions), is that provided by “directly taking these conclusions to the public” by way of news releases, supporting documentation, interviews, etc. for the mass media. Anyone who selfishly puts the wider public at risk for their own gain, deserves all the exposure that the mass media can provide!

¹ Dr. Zsolt Harsanyi & Richard Hutton, GENETIC PROPHECY, Bantam Books, New York, 1982
² John Macdonald, CALLING A HALT TO MINDLESS CHANGE, Amacom, New York, 1998
Chapter #6
IMPLICATIONS

Since there are no “time machines,” we cannot “go” into the future and observe what will be happening then. But experience has taught us that a combination of causal explanations and persistent trends, increases the probability that the forecasts we make will be accurate. Such forecasts are only “guesses” admittedly, but good guesses are better than no anticipation at all. One very wise “rule of thumb” when attempting these guesses, is that the amount of attention a guess deserves is directly proportional to the risk involved in the situation under consideration. If the consequences are trivial, there need be no urgency; if the consequences are important, there should be urgency.

The term “implications,” as used here will refer to the results of deducing future outcomes from present actions. ‘If a vehicle’s continuous movement towards a proximate object is unimpeded, it will eventually, depending on its speed and the intervening distance, impact that object.’ If that object is an insect, it doesn’t matter – if that object is a brick wall, it does matter! By knowing that, the vehicle driver could very likely take evasive action, and prevent the crash. Almost every human action ever undertaken operates on the same rationale. Any number of further complications could be introduced into this situation, but the point remains valid that “to be fore-warned is to be fore-armed.” The keys to avoidance of dangerous impacts are: (a) monitor the situation (watch out for impending impacts); and (b) possess a repertoire of avoidance techniques (take action to avoid serious impacts).

This, in a “nutshell,” is the rationale for Technology Assessment.

This may be fine and well for vehicle drivers, but it often does not sit well with product and system designers and producers. They proclaim the benefits of their efforts, but often ignore the detriments. They spend a lot of time, effort and money developing their “solutions,” and do NOT appreciate “naysayers” or “nervous Nellies.” I, for one, however am a little nervous with the forecast that human consciousness could be loaded onto the internet and could then proceed to “take over” the entire operation of social infrastructure. I am also a little nervous with the forecast that through genetic engineering, superior Homo sapiens could be developed who might then relegate we “lesser human beings” to the role of house pets. If these two forecasts were not bad enough, I am also nervous with the one that suggests we could have all manufacturing done from factories in our garages, thereby undermining employment, the monetary economy and international trade. Lastly, I am nervous about social policy based on Big Data correlations that are merely coincidental, thereby giving governments the excuse to eliminate every social program that does not guarantee supporting votes. YES, I’ll admit it, I am nervous!

Anyone who is not nervous with these kinds of forecasts is either stupid or part of the minority who plan to benefit from these detriments. Furthermore, these are only a few, and NOT the most ominous of the forecasts available. The advice “don’t worry, be happy,” does not really assure me! The future survival and wellbeing of both humanity and the natural environment are being increasingly put at risk by those who only see their solutions as a way to insure their own gain. I propose that we run every proposal and prototype through a rigorous and thorough Technology Assessment – there are too many risks for anything else!
As Donald Norman has pointed out throughout most of his entire career, the implications of products and systems for users, seems to be one of the last considerations entertained by many producers.\textsuperscript{1} If a user has to stop and figure out “how” to operate a particular product or system every time it is used, the delay, frustration and decline in productivity is obvious. Types of products and systems should be designed with obvious features (affordances) that intuitively indicate the proper use (no exceptions unless the reason is overwhelmingly compelling, which it is usually NOT).

When product or system operations require various technical routines, user training will very likely be required. However, gizmos of a particular type should all have the SAME operational routines, so that models from “Producer A” should NOT have exactly the reverse locations or sequences of procedures as models from “Producer B.” If the “proper procedure” for a driver of “automobile A” is to enter by the front door on the driver’s side, the proper procedure for “automobile B” should NOT be to enter by the back door and then climb over the seat into the front (although some of the alternatives in product design are just as ridiculous!). EVERY TIME a stylistic alternative is added which interferes with a functional affordance, it should be condemned and re-designed out of the product or system.

The aforementioned variety of “use” is that which occurs through the “user interface” – there are interfaces between products/system and their users and operators, just as there are technological interfaces between components within a product or system. These user interfaces are the initial ways in which people “engage with” the technology. Beyond initial user however, there is, amongst other things, prolonged use. If a user is supposed to pay attention for extended periods of time, but the combined interface-task is boring, will the user/operator dose off, or get distracted by something more interesting, with the result that the task is not performed properly. If this often occurs, the interface-task should again be re-designed to hold the user’s attention. This is all part of the science of ergonomics, and its application should be mandated.

Long-term use (over extended periods of time) may also have user implications. Computer and keyboard use can cause skeletal wear-and-tear, requiring therapy, occasionally even surgery. Overly bright lights can impair vision in the long term. Too much stress with many technology-related tasks can lead to higher blood pressure and cardio-vascular problems. Similarly, too much bending or reaching can also cause skeletal problems. There are dozens, probably hundreds of technology induced user injuries that may only accumulate to a “trouble threshold” after months or years of sustained interaction.

\textsuperscript{1} Donald Norman, THE DESIGN OF EVERYDAY THINGS, Doubleday Currency, New York, 1988
Another user implication of technology operation, is the prospect of dysfunction with the product or system. The interface could be adequately “user-friendly” and the task could be sufficiently interesting that the user is properly engaged, BUT a malfunction or emergency might occur for which the training provided is not suitable. Major industrial accidents have arisen out of these kinds of circumstances. The previous training explained what to do when the technology operated “properly,” but not what to do if the technology does NOT operate properly. These are the kinds of accident-prone situations that are often attributed to “human error,” it being easier for owners and designers to blame someone else rather than themselves.

It is also possible for an initial malfunction to begin cascading through a product or system, and in the process spreading the malfunction far and wide. Electrical power black-outs occur this way. Traffic pile-ups that start with a single collision and go from bumper to bumper down the line, are another example. A computer virus or piece of malware may infect an entire intra-net or extended network, breaching security and/or shutting everything down. User mistakes may initiate such malfunctions, OR ignorance may render operators or users completely incapable of correcting the problem. Once again, the favorite cause is attributed to “human error” (but not producer error or designer error!).

There are certain types of testing software that purport of be able to uncover “ALL” of the prospective kinds of product or system malfunctions, thereby locating the vulnerable spots in the design that can be corrected and re-tested (perhaps multiple times to assure that new design alternatives do not “create” their own new vulnerabilities). “Obviously” there are NOT such software to test ALL products and systems, otherwise we would not experience so many breakdowns, malfunctions, and accidents. However, this would be a very worthwhile area for investment, research and development. This is one suggestion that Technology Assessors could make to governments EVERYTIME A MALFUNCTION OCCURRED!

Another implication of user-technology interaction would be the possibility of operator sabotage. People do commit suicide by crashing their cars, or gassing themselves with exhaust. People also kill other people by purposefully crashing into them or gassing them with exhaust. In addition however, sometimes operators “throw a wrench into the gears,” either to wreck the technology or to give them some off during repairs. Both domestic and international terrorists are accused of using spies to locate technology vulnerabilities that can then be sabotaged in a coordinated fashion, thereby jeopardizing national security and leaving the population open to termination of essential services. But, even when these charges of terrorist plotting are true, there are national and regional intelligence services tasked with the responsibility of counter-intelligence and counter-terrorism. Contrary to what many assume however, there is no credible way of evaluating the motivation of the workforce that is actually operating the technology. In this respect, the safest design strategy would be to design controls so that users could properly operate technologies, but could NOT improperly operate them. This is done occasionally, but more is needed – another good Technology Assessment suggestion.
TECHNOLOGY IMPLICATIONS

Technology is not a “free good” in the sense that it never has to be paid for – even users and operators pay, through purchase prices, lower wages or government taxes. However, many people think about, or use many technologies AS IF they were free goods. Is that a bad idea? Often, yes, because the careless disregard with which they use many products and systems increases their wear-and-tear and the chances of malfunction.

Whether or not there is careless disregard by users however, the implications of technological wear-and-tear are important to recognize. Firstly, technologies are often not designed or built to withstand the use-loads that are placed on them. Dams were formerly designed with a considerable “safety factor” built into them. As much as 50% to 100% of extra load-bearing capacity was regarded as advisable. With these structures, there were very rarely failures.

Why was the safety factor reduced? The answer is simple: cost. Most of the people who design and build the dams did not live in the valley downstream from the dams. So for them, the major concern was minimizing costs. If a stronger dam for a very large flood, was calculated to be very rarely needed, a lesser structure was considered adequate. But if rare floods occur randomly, the “one in a thousand years flood” could as likely occur in the next decade as it could nine hundred years from now! Regrettably, some of those rare floods did occur, and dams did burst.

Technological products and systems have many other cost implications. Another important source of costs is Maintenance and Repairs. One recent trend is to “slack off” on the maintenance and repairs expenditures for social infrastructure (roads, bridges, sewage systems, water supply systems, electrical transmission lines, etc.). It turns out that “upkeep” on these facilities is really quite expensive. Therefore, when governments are squeezed for funds (and what government isn’t squeezed for funds?), decisions are made to lengthen the periods between inspections, and to reduce spending on repairs by focusing on obvious and urgent targets. As a result, bridges have collapsed, sewers have broken, power lines have malfunctioned, etc.

Part of the problem with Maintenance and Repair, is the quality of the original product or system – it has been substandard. This saves money on initial construction or purchase price. But in the long run that means more maintenance and repairs throughout the lifetime of use. However, as previously mentioned, governments are trying to save money with this as well. So the overall result is that the public is being placed at increased risk just by driving across a bridge or drinking water from a tap. It is undoubtedly time to “rethink” our entire approach to infrastructure, so that safety and performance can be increased AND costs can be reduced AT THE SAME TIME. This is a particularly important challenge for Technology Assessment.
Yet another source of increasing costs is the process of technological updates or upgrades. Electronic products and systems have “bought in” to this in a major way. The rationale for these practices seems “reasonable” until, that is, the rates and costs are specified. But with electronics R&D supported by million$, the upgrades and new gizmos are being developed and deployed at a healthy pace. Furthermore, designers and producers are working together to change critical components and interfaces in new models so that older models will simply not work with the new upgrades. So technology users, once on this treadmill, have to replace significant portions of their products and systems just to be able to continue to provide the functionality that is an essential part of their businesses. Technology Assessment could usefully consider whether the design paradigm on which these changes are based should not be changed to make previous models compatible for something like the previous ten generations of products! This is entirely feasible, BUT it will take a fundamental change to design and marketing.

The other cost of this “upgrade” process, is the cost of obsolescing older equipment. The more upgrades that come out, the more that older products and systems are “retired.” Tube television sets are being replaced by flat screens. Many land-fill site managers do not want these tub sets in the ground – so special disposal arrangements must often be made. The same often applies to other electronic equipment that is being “de-commissioned.” Amongst other things, electronic discards are often “mined” for small deposits of precious and semi-precious metals – those that are used for their unusual electrical properties in certain Interfaces and Components. The main thing is, this all takes special arrangements, and requires special efforts, which are not costless.

Even when obsolete equipment can bring in some “scrap value,” this by no means covers the losses suffered by having to “write off” the old stuff, and purchase the new stuff. Depending on what, and how much is actually being replaced, entire sections of organizations may have to be taken out of service while conversion occurs. If the new equipment will be coexisting with some older equipment, interfaces and interconnectivity must be re-established, AND tested to assure that the new arrangement actually works. Again, more time, more effort, more money. On top of all of this, the operators must be retrained, or else new one already trained must be hired. It usually turns out that the dynamics of the system have been changed to one degree or another. Some of these changes will be immediately apparent, but some of them will only manifest themselves after considerable time of operation, OR when very unusual circumstances occur. Some of these changes may be benefits, but the detriments can be a real “pain in the neck.”

Technology Assessment should always bear in mind the costs, of both doing things and not doing things. “Opportunity costs” is the appropriate term – what you do technology-wise is bound to be expensive, but what you don’t do may ultimately cost you more in terms of opportunities foregone. Once again, the task is to recognize the necessity of trade-offs.
SOCIAL IMPLICATIONS

One real problem with Social Implications, is that all too often those who are trying to discover the social implications of technology, OR trying to ignore them, seem to assume that they somehow have an insight into how people feel or think. A similar assumption often arises in marketing as well. Doing research to determine what attitudes or opinions people actually have, appears to be the last option considered, and only then after either consulting with experts or guessing have both proven wrong!

A number of reasons have been offered for this reluctance to ask or observe “the people.” Perhaps people don’t have any specific views on an issue. Perhaps they cannot effectively articulate whatever views they do have. Maybe they will not be straightforward, or even honest about their views. Perhaps their views on the issue under consideration are confused with other irrelevant issues. Perhaps there isn’t the time or money to do proper research, so the decision is made to rely on “common knowledge” or “local gossip.”

Two causes for these attitudes seem prevalent: (1) sometimes there is just no desire to hear from the public; and (2) at other times there just isn’t the desire to do the work required. Both attitudes are patently foolish, but still widespread amongst designers and producers. The social implication of these attitudes is that although the public is needed as consumers, operators and users of technology, they are not respected enough to be involved as partners in the design or deployment processes. Talk about being shortsighted!

Innovations are not “God’s gift” to a grateful humanity, nor “evidence that we live in a worldly paradise” – yet this is precisely the attitude that seems to lie behind much of marketing. Everything from new cars to new cold medicines, is sold as if it can provide the answer to the most meaningful questions ever asked, and/or solve the most difficult problem ever encountered. For every modest advertisement there are 99 others using excess hype, and making exaggerated claims. Given these attitudes by designers and producers, it is not surprising that there is not a lot of enthusiasm for “public accountability.”

Getting Technology Assessment onto the public agenda is therefore going to be an uphill battle. However, that is all the more reason for why it is needed. There will likely be two sources of social implications regarding technology design and deployment. Designers and producers will be one “hurdle.” The other “hurdle” will be the attitudes of the very public that Technology Assessment was meant to protect. People buy and/or use the many products and systems that sooner or later are the source of so many detriments. What are the implications of this second “hurdle?”

The question of “why” the general public is often so ready, even eager, to buy and/or use products and systems that have not been properly assessed and evaluated BEFORE deployment, is a controversial and troubling one. One explanation buts the blame for this negligence squarely on the producers’
methods of promotion (propaganda and advertising). According to this view, people are psychologically manipulated into wanting and using new technologies based on superficial features rather than true needs. “Product and system promotion” is definitely a multi-million dollar industry, but in the majority of cases the producers who use it are seeking to increase market share, rather than substantially change consumer tastes. When consumers “don’t want” what is being offered, a commercial failure results.

It seems therefore that consumers like the commercial availability of tools and toys. They “appear” to make circumstances more convenient and easier (a superficial observation). With the modern world’s emphasis on individualism, people often slip into an ethical stance of “exceptionalism” – which amounts to the attitude “hold other people to high standards, but in my own case let me have my own way!” Their rationale when using such exceptionalism, is that in most cases, the behavior of a single person will make little difference one way or another. In a strictly limited sense this may be true, but if many people behave this way it produces a trend nonetheless. What Technology Assessment should encourage at the individual level, is the recognition “if you are not part of the solution, you are part of the problem!”

There are other important social implications of technology use as well. Sometimes products and systems which are reputed to “change everything” turn out to be merely additional milestones on a well-worn path. On the other hand, what are announced as just minor modifications may inadvertently cross a parametric or systemic threshold and produce a fundamental impact. How can Technology Assessors tell which is which? Looking at products or systems from a parametric or systemic point of view, rather than just using superficial “observation,” would surely help. However, many of these impacts will only manifest themselves “downstream” from their deployment. Persistent television use disrupted both student homework AND family dining patterns. Mobile phones caused traffic accidents and privacy invasion. None of these results were obvious when the technologies were introduced.

Use-patterns have to be continuously monitored to discern these effects. Major disruptions can then be avoided or rectified, and minor ones can at least be recognized. How much disruption can people reasonably expect to accommodate or avoid? One part of the answer depends on the people themselves – they have to be engaged in a conversation about the issue, the problem, and any proposed solutions. Another part of the answer depends on the context for the proposed technology. Has a “real need” been identified, has a feasible solution been proposed, will the solution actually work, and are the impacts foreseeable? The role of Technology Assessment is to help answer these questions, and provide a strategy for implementing the agreed plan of action.

Modern technology has certainly created a new world-view. To a considerable extent the safety, security and wellbeing we enjoy are greater than at any previous time. Nevertheless, we need to take the time to distinguish between technological benefits and detriments, so that we can accept the former, and reject the latter. It won’t happen automatically – vigilance is the price of survival.
OUTCOME IMPLICATIONS

Sometimes the implications of “normal” functioning are just as questionable as those of malfunctioning. “We did everything right” may not prevent an accident or a detriment. Why or how does this happen? One answer is, very (radically) different interpretations of a technology assessment or evaluation. Many radical environmentalists oppose almost all of the current human interventions in the environment. Elitists oppose any and all attempts to equalize wealth or power in society. Many religious believers oppose both atheists and practitioners of alternate faiths. General Charles DE Gaulle (a tall man) once told Economist John Kenneth Galbraith (another tall man) to never trust short people. Those who hold such views are NOT necessarily going to accept judgments or assurances that do not confirm their prejudices. The best that can be achieved under these circumstances is the “least worst solution.”

Others believe that outcome implications depend on whether the technologies are incremental or disruptive. That however, may depend on how you define “incremental” and “disruptive,” and which ones you accept or oppose. I regard all of the Windows operating system software upgrades from version one to version seven, as being merely incremental. However, I regard the “upgrade” to version eight as a radical disruption of a formerly comprehensible system! Others see it as merely the replacement of a conceptual interface with a perceptual interface! Some people like the change, but other won’t use it (it might even inspire some of the latter to recommend Technology Assessment to cope with such cases).

Another dimensional implication is the difference between superficial or deep (fundamental) impacts. One routinely used claim is that technological changes are usually either widespread and superficial, or deep but narrow (confined to one aspect or parameter). However, most users may not experience or recognize deep changes anyway. If the change comes at the functionality or interface levels, more reliability or safety may not even be noticed. But since people do pay attention to superficial changes, a new color or style alternative may get immediate approval or disapproval. It would be nice if some conventional slogan such as “the customer is always right” could be our guide, but THAT would almost immediately lead to a sacrifice of Quality for Appearance, as is always threatening to happen!

One particularly exasperating occurrence is the advent of temporary vs. permanent implications. Some people (analysts or otherwise) have a favorite “issue hobby-horse” they will ride whenever the opportunity presents itself. If such an issue happens to be a technologically induced outcome, concerns are immediately raised, often in a public forum. What may subsequently happen though is that this induced outcome may only be temporary. People’s attention may be attracted by a novel situation, but once the situation persists for a little while, people may get used to it, the novelty evaporates, and the implication (people’s distraction) was only temporary. Just as frequently however, there do not appear to be any noticeable
implications immediately, but over an extended period of time they begin to emerge. Furthermore, what does emerge seems as if it will likely last. Traffic jams do not necessarily occur during the first few weeks or months after a new road opens. Only later does a “location of interest” get built at one end of the road (a shopping plaza, sports arena, cinema complex, etc.), and heavy use jumps thereafter. The traffic jams will now persist as long as the road and the location of interest continue to exist. This joint cause of traffic jams is an example of both an emergence effect and a by-product effect – without the location of interest as a by-product of the presence of the new road, there might still have been no traffic jams.

Outcome implications can also be found in proportionate and disproportionate instances. A major technological change might seem to be the sort that would have impacts and concerns over a wide area and/or a large proportion of the public. But, surprise, surprise, nothing much seems to happen or no one much seems particularly upset. If a famous company, or a favorite product ceases to exist, there might have been a time (in their early days) when there would have been public outcries and indignation. But their very success may have encouraged competitors who eventually gain significant market share – with the result that there are supply alternatives, and the loss is “no big deal.”

Lastly there are the implications of “decommissioning” – retiring or scraping old technologies. No product or system can last forever. Sooner or later a major overhaul or complete replacement will be necessary, IF the functionality being provided is still needed. What this last point implies is that some functionality may itself become obsolete. Most of us are familiar with the “stories” about how manure sweeps of the streets were no longer necessary when horses were replaced in the road transportation system. Once cameras become digital, there is no more need for film, or film processing equipment, or film processing facilities. There old products have to be disposed of. There are also the people employed in these obsolete industries, who will need re-training or help in finding new jobs.

In cases where products or equipment are simply being replaced, the same factories or offices buildings may still be used, but considerable layout and organizational changes may also be in store. Work schedules may need to be changed, supply arrangements may need to be re-thought and re-contracted. If part of the new installation involves removing the old equipment, that problem is settled – if the owner has to manage the removal of facilities from the premises, AND the disposal of them once “out of the way,” there are more cost and handling implications. Advertisements often portray such changes with phrases like “off with the old, on with the new.” But the costs, manpower requirements and responsibilities involved are anything but easy or quick.

Technology Assessment should always look at these “adjustment” implications as part of technology deployment. Lessons from these experiences may also be shared to help ease the transition to improved technology. We can’t foresee everything, but we can stay alert.
INCLUSIVE IMPLICATIONS

The general implication of technological deployment is that some of the impacts will be benefits, and some will be detriments, but both types should be included in the evaluation and monitoring of products and systems. Anticipated benefits still need to be understood and accommodated – just because their effects are positive doesn’t mean nothing more should be understood or done about them. If benefits are not recognized and integrated into use-patterns, they may be overlooked or ignored. In terms of existing technologies, many of the features are not known, even by experienced users. Newer products and systems are likely to be even more of a mystery. In this regard, the proper training is rarely provided.¹

The implication of technological detriments need to be understood and dealt with to an even greater extent than benefits. The single most pertinent rationale for Technology Assessment is to avoid or alleviate technological detriments. Every lesson learned with technology has the potential to contribute to increasing the benefits and/or decreasing the detriments. Sometimes the “clues” about what is coming “down the pipeline” are subtle or esoteric, at least to those without the experience to know what to look for. When parts of a piece of equipment vibrate in resonance with the power source, this can often inform an experienced operator that things are either “going really well” or “not going very well” at that particular speed of operation. This may be the first clue in a sequence of steps with important implications. That is the kind of observation Technology Assessment should look to record and share.

Another aspect of this inclusiveness is the question of desirability or undesirability. These considerations are NOT the same as benefits and detriments. Various groups may desire various new technologies for various reasons. Enjoyment is one reason. If the sales figures are to be believed, the consumers of new video games REALLY desire them – the first week sales figures are often phenomenal. But does persistent use of these “desirable” technologies lead to good long-term results? It depends on who you ask! A number of psychologists have done in-depth studies of the results of video game use, and some of the results show implications. Perhaps users of violent video games themselves become inured to the use of violence in general. There is also some evidence they become more socially isolated and more narcissistic, which can lead to anti-social behavior in other relationships.

Some groups desire some technologies for ideological reasons. Some regard the potential of genetic engineering to be the opportunity to eliminate certain characteristic from the human gene pool. Others would go ever further, and breed a new “trans-human” that was possibly superior but certainly different from existing human beings. Such people are completely serious in their intentions, and want no assessment, evaluation or controls placed on genetic

¹ Paul A. Strassmann, THE SQUANDERED COMPUTER, Information Economics Press, 1997
engineering. If we comply, humanity will participate in phasing itself out! By comparison, other desires are less extreme, but still fraught with risks.

Governments in developed countries are attempting (often successfully) to move the delivery of their services onto the Internet wherever possible. For some government services however, the recipients do not have the requisite computers to enable them to participate in this new arrangement. These same recipients may not have bank accounts, so they can't receive their stipends via electronic transfer. Such governments often attempt to have enquiries and complaints routed to them through e-mails to suitable websites. All of these moves are premised on computerizing interaction because of cost savings, but they thereby exclude anyone not able or willing to communicate electronically. Is this a strategy that really respects democratic and citizenship rights? Here again is something Technology Assessment should take a serious look at.

One troublesome aspect of inclusive implications is the kind of situation where some people passionately desire a particular technological outcome, but others are just as passionately opposed to it. One possible solution would be to enable both groups to have their way, but in separate locations or contexts. But what happens when the aim of one group is to see its desired technological outcome available EVERYWHERE, and another group is opposed to this same technological outcome ANYWHERE? We see examples in other social spheres quite frequently. Certain religious believers want the state to adopt and enforce their religious practices. Others oppose any religious practices in governments or by governments at all. In terms of technology, some people want private car ownership and use discontinued. Others see privately owned cars as the solution to the entire urban transportation challenge.

How should Technology Assessment deal with these kinds of conflicting desires or conflicting views? With two processes: participation and negotiation. In both the assessment of design and deployment, opportunities should be made available for a representative sample of “concerned citizens” to participate in defining “technological implications,” evaluating their impacts, and negotiating resolution of conflicts. The outcomes will not necessarily be to anyone’s complete satisfaction, but in the process both the benefits and detriments of technologies will be clarified, so that ways can be found to promote the benefits and discourage the detriments. The intention is not to produce a perfect world or perfect public policy, but to increase safety, security and satisfaction while using what would otherwise be increasingly risky technologies.

Even with Technology Assessment it will not be possible to foresee every single detriment that will occur because of technology use. But if a large proportion of such detriments can be identified, understood, and either avoided or ameliorated, then the resources and wherewithal to cope with those we don’t anticipate, can be readily available when they do emerge. Though again not perfect, this will considerably better performance than would otherwise be the case.
When a Technology Assessment anticipates or discovers malfunctions or undesirable performance in technological products or systems, one possible approach to rectification is through re-design. One possible suggestion in these circumstances is to change to a modular design paradigm, if that is not already being used. Beyond that, the task of the Assessors is to track the malfunction or performance problems to their cause in the technology. The point about Modular Design is that once a problem has been uncovered, it is important not only to correct it, but to learn the lesson and avoid similar design mistakes in the future. If the same retrofit for the same type of problem occurs again and again, there is something seriously wrong with the prevailing design paradigm.

As was mentioned with regards to Implications, Technology Assessment should make helpful suggestions not only for detriments, but for benefits as well. Retrofits also have a role here. This can be facilitated with the concept of “alignment.” When a number of technologies are contributing to achieve a particular outcome, it helps if they are designed with complementary functionality and/or performance – in other words, they should work well together. This is particularly true when the intention is to improve productivity or performance with the arrangement. Technological Interfaces and Interactions should be designed or re-designed so that the costs of operation are minimized and outputs are optimized in ways feasible for performance and productivity enhancement.

Although re-design can often deal with retrofits, in some cases recall is necessary. If the design is not modularized, its complexity could very likely necessitate a recall in order to redesign and then retrofit the product or system, provided that was even possible. Complex designs often require that major changes can only be done if the entire configuration is rearranged to produce the new functionality. That means back to the drawing board and perhaps a repetition of the entire R&D process. That kind of recall should only have to happen once to a producer and the lesson should then be clear – transition to Modular Design so that components can be redesigned and replaced without the entire product or system having to be “re-invented.”

One of the most likely circumstances to impel recall is the prospect of serious environmental harm. But depending on the particular product or system, the type and extent of anticipated environmental harm, and the stage of deployment, re-design or re-configuration may do just as well. Whichever of the four (retrofitting, re-design, re-configuration, or recall) will provide the best opportunity for rectifying the problem, is the best choice for Technology Assessment to recommend. The same principle can also be the “line of defense” for dealing with future emerging impacts. Experience will likely reveal which of the four is appropriate to particular technologies, different kinds of impacts, or the various goals the Technology Assessment process is prioritizing (enhancing benefits, eliminating detriments or achieving compromise between various ideologies or interest groups).

The important point about retrofits is that designs are not “cast in stone,” but rather may need improvement for a variety of reasons. The realization that Technology Assessment may recommend retrofits of some other change(s) should motivate producers to do a better job in the first place.
When something goes wrong with a technology, fix it; if the cause of the malfunction or performance problem can be located in the design of the product or system, re-design it. It sounds simple enough, but the practice is rarely so simple. Designers and producers may respond to evidence of malfunction or performance unacceptability, by claiming “the problem” lies not with the design but with the way it is “misused.” Their contention is that if the technology was used as the manual instructed, there would be none of the “problems” that users are encountering. In at least some cases this is likely correct, but that doesn’t solve “the problem.” The problem then becomes “how can the product or system be re-designed to discourage users from misuse?” This term for the design strategy to either encourage (proper use) or discourage (improper use) is “the nudge!”

Using the “nudge” in design results in the proper use being convenient, whereas the improper use is (very) inconvenient. Designing mobile phones so they would not operate within a car is an example of a “nudge.” If people wanted to ride strapped to the roof, of lean half-way out of the car window, they might still be able to use the mobile phone, but this “nudge” would discourage the vast majority of such use while riding in cars.

Some users feign great alarm regarding this kind of strategy – “we have the right to decide for ourselves regarding mobile phone use in cars” they contend. But NO, they do NOT have that right. Most roads are publicly owned and operated, and the respective jurisdictions have the “right” to set conditions of use. EVERY sensible jurisdiction should outlaw the use of mobile phones in cars. Then the aforementioned “nudge” works in cooperation with such laws to minimize misuse.

Experience demonstrates that average users do not always behave in a sensible or safe way when using technologies. Design should therefore provide as many “nudges” as possible to discourage misuse, and encourage proper use. The other side of this issue, is that some malfunction and performance problems do not arise from operator misuse, but from poor safety provisions or improper instructions (i.e. from bad design). Development and prototype testing should be as comprehensive and rigorous as possible – often in the rush to market, they are not. In other cases, the circumstances which produced a problem were just not foreseeable. But however it happened, the occurrence or prospect of serious problems demands significant changes, quite often by way of re-design.

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How wide-ranging should re-design recommendations and efforts actually be? That will depend on the communities wherein the uses will be occurring. One of the mantras of the post-modern world is “the value of diversity.” Just as there is individual diversity, there is also community diversity. Individual diversity is governed by specifying both individual rights and responsibilities. Community diversity can be governed with the same provisions. Different communities may want different degrees of “technological involvement.” Within limits this is feasible, but only if wider societal rights and responsibilities are acknowledged and respected.

If a community of users prefers to forego certain technological accoutrements, providing there is voluntary community consensus, that community may select at least some of the products and systems to adopt or ignore. Insofar as these community members interact with other communities however, they must possess the wherewithal to do so. In addition, they must not deny any of their members access to the technologies usually foregone IF those members change their minds for any reason. Can this work? It could undoubtedly be designed to work, and any of those committed enough to try it would be welcomed to it. As a matter of interest, these communities could also use “nudges” to encourage and discourage their preferred technology uses, just as the wider society could.

How would those with different use-preferences manage their own behavior across the various communities with which they maintain contact or interact? The answer is role flexibility and role switching. When I visit my Mennonite friends, I don’t wear a yellow and purple striped suit, not do I expect to watch a sports event on a television that they don’t have! By the same token, when they visit me, I pick them up in my car which they agree to ride in, and we do listen to music on the car radio – we both adjust depending on circumstances.

Those who don’t use as much technology will likely experience fewer detriments, but fewer benefits as well. But regardless of the extent of use, some technologically-induced mistakes and accidents will occur. If these occurrence persist and are widespread, Technology Assessment can identify them and contrive ways to reduce or eliminate them. Even those who are not direct users or operators will likely be impacted by malfunction and performance problems that become systemic in nature (pollute the environment or undermine the society). It bears repeating that there is no such thing as “generic technological progress!” More efficiency is regressive if stifles human creativity. More automation is regressive if it undermines local economies. More education is regressive if it encourages intellectual elitism. In many cases, efficiency, automation and education DO produce these regressive outcomes. What counts is not the rhetoric or the ideology, but the performance. The Enlightenment was premised on applying science for human betterment. When the results are not better, the application is NOT enlightened. Technology Assessment recommends change for the better!

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2 R.S. Jenkins, CANADIAN CIVICS, The Copp Clark Company, Toronto, 1909
Technology can be an instrument for helping produce a better world, but this will not happen automatically “as if by a hidden hand.” The “hidden hand” metaphor was employed by Adam Smith in the very early days of the development of Political Economy (the “umbrella social science” back in the 16th, 17th and 18th centuries). Neither Anthropology, nor Sociology nor Psychology existed in those days. Out of Natural Philosophy and Moral Philosophy, Political Economy was the first of the social sciences to be articulated because it had a ready audience and sponsors (rulers).

What the “hidden hand” metaphor referred to was the sets of folkways and mores prevalent in the various communities. Smith’s account of the emergence and functioning of markets was only possible because sovereign states created and propagated the “rules of the game” that were needed to make markets work. Property was protected, and so were borders. Only in this way could market come into existence and begin to organize production and distribution. So the notion the order of society was the result of a “hidden” hand only made sense at that time because no one was really sure how to study societal processes.

In the 19th and 20th centuries, effective and reliable methods to study social behavior were developed, tested, and widely used. Such luminaries as Durkheim, Weber, Sumner and Spencer conducted research and proposed theories that showed some shape to human endeavors. The only reason why social dynamics appear to be guided by a “hidden hand” is because the “patterns of behavior and attitude” arise out of the community’s experience rather than being legislated and proclaimed. Furthermore, there is a degree of adaptability residing in these folkways and mores – in some ways traditions are very resistant to change, but in other respects they transform to meet their users’ needs.

There is no “hidden hand” guiding society or the economy. Producers use this rhetoric as a kind of “sleight of hand” to argue for as few regulations as possible. However, they do NOT argue for no laws, no property protection, no police, no economic contracts, no tax breaks, no investment credits, etc. Yet without all of these “heavy hands” there would be no modern society or economy! So, producers want other peoples’ behavior regulated enough to be able to conduct secure business transactions, but they only want their own behavior regulated enough protect their “climate of investment” and respect their “rates of return.”

What has any of the foregoing got to do with Technology Assessment? Everything! In the analysis of technology, context is as important as content. Very early on in the application of science to social betterment, those with money to invest realized that they could turn “the provision of social betterment” into a number of thriving businesses. Steam engines made coal mining more efficient, and more profitable. Power looms made cloth weaving more productive, and more profitable. User-friendly software made computer work more effective, and more profitable. Smart mobile phones made communication much more convenient, and more profitable. You get the picture – whatever
benefits the customers are looking for, the producers are ALWAYS primarily looking for profitable exchange. As the producers are fond of saying, any who don’t make a profit don’t remain in business, so they regard their priority as perfectly understandable and justifiable. This last claim is not entirely correct; remaining in business only requires that revenues cover all expenses – it would be entirely feasible to run a business by simply covering expenses, and investing any surplus in either service improvement or lowering customer prices. However this usually only happens in very competitive situations.

Nevertheless, it should be possible to “align” provision of public benefits and gaining of producers’ profitability so that they complement one another. But in order to do so, everyone involved must keep in mind that both of these objectives must be pursued simultaneously. If producers ignore their social obligation (to produce public benefits), Technology Assessment should remind them, in no uncertain terms, that these are part of the requirements of their role in society. Similarly, society in general, and Technology Assessors in particular, must not expect or propose behaviors to producers that will undermine their economic existence.

What alternatives does that balance offer? Technological products and systems can be produced that function together in complementary ways, through the use of Modular Design by way of Standardized Interfaces and Compatible Interactions. Those who try to justify idiosyncratic coupling arrangements to “protect their intellectual property” are really just saying that their money-making is more important than any inconvenience or imcompatibility they are imposing on customers! Technology Assessment is an opportunity to confront such intransigence, and suggest better arrangements.

Wasting resources, harming the environment, compromising safety or jeopardizing security, should not be intentionally pursued or unintentionally tolerated. Insofar as these unacceptable outcomes result from technology operation and/or use, Technology Assessment is used to alert us to these problems, and suggest solutions to them. But the suggestions can go further than just proposing corrections to detriments. Technology Assessment can provide guidance for how better design, deployment and operation of technology can actually improve social operations and customer satisfaction.

Prior told World War One, each manufacturer of light bulbs had their own size and configuration of light bulb sockets. Many other consumer products were designed the same way. In order to effectively supply the war effort, governments imposed standardized sizes and designs on many such products. However there still remain far too many types and sizes of product and system Interfaces and Interactions. There is no good reason why the entire technological infrastructure society uses should not be interconnected to achieve minimum cost and maximum productivity. At the same time, security features (like load-shedding) could be built into the system so that in case of accidents or emergencies, problem components or zones of the network could be isolated so that the troubles could be confined to particular locales or functions as effectively as possible. This can be the larger goal towards which Technology Assessment could be oriented. All the lessons learned from Technology Assessment could be applied to this project, a social goal for technological improvement.
Re-designing or recalling products or systems to increase societal benefits and decrease societal detriments, may sound as if it will repeat previous points, but that is not the plan. The retrofits to be discussed here refer to jointly or collectively used technologies rather than individually operated products or systems. As an example, should we build more roads because people want to use them? If governments saturate the “market for roads,” then building will only stop when either demand stops or use of some of the new roads declines or stops. Besides being a waste of at least some of this money, there are other priorities for government spending in addition to building roads.

If we look at the various forms of societal infrastructure (transportation, communication, housing, education, etc.), how much more of each is needed, what particular kinds of additions are appropriate, and how do we assure than present or future detriments are eliminated as expeditiously as possible? Let’s begin with the first question. How much more production of consumer goods is needed, or enough? Anyone who does not have an “adequate” supply of any products or access to any systems, could very likely contend that when their needs are met regarding the technology in question, then that will be enough. What would be the societal results of attempting this “solution?”

The originator of the concept of Nanotechnology claims that micro-miniaturized machines could eventually be developed that will enable small “factories in a box” to be located in every garage.1 “Synthetic materials” will be the feedstock for such “factories,” and they could be programmed to turn out any consumer product that was desired. Given the number of those with unsatisfied consumer demands, and the long lists of those demands, what would be the societal consequences? Once such factories were obtained, every older model of every consumer product could be discarded. Where would these discards go? Into the municipal garbage pick-up and disposal. What would be the result? Every land-fill site in the country would be filled almost immediately – but the stream of discards would just keep coming! There would be no market for second-hand anything because everyone could get some new stuff! Perhaps an international charity drive for certain items would ease the glut of junk temporarily, but not for long. Does anyone regard this scenario as implausible and unlikely? IT IS NOT! It is precisely the way most people would behave, given the change, for decades, perhaps even a couple of generations. By the time good sense returned to consumers, the ecology of the planet would be devastated! Be careful what you wish for!!!!!! It could lead to societal ruination.

Furthermore, this is only one half of the prospective problem. The other half would be the glut of products that would come into use as a result of these “factories in a box.” Many consumers

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1 K. Eric Drexler, RADICAL ABUNDANCE,
would become hoarders of their own productive output! They could produce more cars, chairs, tables, clothes, bicycles, refrigerators, stoves, television sets, etc., etc., etc. than they had ever purchased before. And why not?! Such levels of consumption are often identified with high status. Once again, does anyone regard this scenario as implausible or unlikely? IT IS NOT! How can the detriments of both halves of this problem be retrofitted? The ONLY feasible strategy is to prevent the situation from arising in the first place – once these “factories in a box” were deployed, it would be incredibly difficult to recall them. OR to limit their use. The societal impacts of this technology would create detriments that would swamp any society’s capacity to cope. Like the widespread deployment of nuclear weapons, the deployment of this technology would be suicidal.

There are other technological proposals that deserve the same terminal retrofits if we want to focus on human wellbeing rather than a technological treadmill. Info-technology has advanced so rapidly and been applied so widely that it is now an aspect of the entire global culture. One enthusiastic supporter of this trend titled his book THE NAKED FUTURE. What he foresees is the “intrusion” of big data collection into every facet of life. The result will be very much less privacy (some say none!), but the benefits are supposed to be so spectacular that it’s worth it. Your clothes will monitor your health and report to your doctor, who in turn will prepare the appropriate medical intervention, if you have a health problem emerging. If your personal finances encounter either new risks or new investment opportunities, your financial advisor will immediately begin preparing a proposal so you can respond properly. On the basis of your purchasing patterns, any sales of goods you favor will be brought to your attention so you can continue saving by spending! If you are looking for a date, or looking to get out of a date, there will be plenty of “personal relationships advice” available to you at the push of a button. Nothing that you do, have done, or could possibly imagine wanting to do, would be outside the bounds of “communication companion.”

However, many people would prefer to protect their privacy and have much less to do with the “communication companion.” How do we retrofit this one? Ways must be found to give either option that a person wants. Those who have designed the “communications companion” should now work on “selective deployment” only amongst those who want the service. The goal would be to enable selective deployment through individually customizing the “services” involved. How? That is the next task that Technology Assessment should assign to those clever people who created the “communications companion” in the first place.

The moral of these stories is that there is more to societal effects than just what people want. The “systemic” results of satisfaction may be no more desirable than the results of dissatisfaction! Retrofitting will require just as much ingenuity as the initial design.

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ENVIRONMENTAL RETROFITS

The necessity for environmental retrofits is based on the reliance that all life-forms have regarding their environment. Most fauna life-forms (animals) on this planet breathe in oxygen and breathe out carbon dioxide. On the other hand, most flora (plants) breathe in carbon dioxide and breathe out oxygen. Any social and industrial processes also use “extra” oxygen in their processes. So, it in humanity’s interests to keep a plentiful and healthy flora alive and well on this planet! So why are we systematically destroying this planet’s “greenery?” Because we are, collectively, short-sighted and narrow-minded!

A significant proportion of our social psychology is based on our past traditions rather than our future challenges. Since the development of science during the Enlightenment, and its application to our way of life since then, we had so radically altered the terms and conditions of our lives that the folkways and mores of “hunting and gathering” or “sedentary agriculture” have become a completely inadequate basis for organizing our activities and lifestyles – yet we persist in short-sighted and narrow-minded routines. Time and time again we exploit ecosystems beyond the point of sustainability, whereupon they either cease production or require increasingly expensive inputs.

If humanity continues degrading land and water systems, we will eventually exhaust even our technology’s capabilities of enhancing the earth’s carrying capacity. As population keeps increasing, the natural productivity of more and more areas keeps declining. So far this has often been off-set by inputs of artificial nutrients, but they are both energy-intensive and cumulatively toxic. This kind of environmental harm is self-defeating! Fortunately, many such cases have been publicized, so human societies are beginning to limit some of human-caused environmental damage. At this point in time however, the offending technologies are so widespread, that recall is seldom feasible, so retrofits are the next best thing.

There are two aspects to this kind of problem: (1) Instances of environmental damage and degradation are treated as localized exceptions; and (2) solutions are designed and administered in a piece-meal pattern.

What kinds of retrofits does this include? For one, human settlements should be restricted on waterway flood plains. Protective dykes only provide a (temporary) illusion of protection, as Hurricane Katrina, and other Mississippi Valley floods have demonstrated! Many insurance companies have now recognized this imperative, and will only pay claims for restoration IF the buildings are located elsewhere. Long-term relocation in these cases is the only environmentally responsible strategy.

Settlements should also be restricted on agricultural land. Denser housing accommodations should replace proliferating suburbs. Re-housing should commence as soon as possible – not single-family
houses OR high rises, but low-rise units. This design is the best compromise between low environmental impact and effective social design.\footnote{Robert Sommer, \textit{SOCIAL DESIGN}, Prentice-Hall, Englewood Cliffs, 1983}

Garbage disposal in either land-fill sites or off-shore sea beds should also be banned, and existing disposal areas reclaimed, so that those former disposal site can be environmentally re-conditioned and returned to safe ecological functioning. ALL garbage should be processed to that human resource consumption is a closed-cycle system in so far as possible. Organic waste can be put into processes so that methane gas is generated, and the residue could be used for fertilizer or chemical feedstock. Other materials could be recycled and reclaimed for further use in one way or another. Those who believe that these environmental retrofits are not really necessary, or too extreme, or will not be effective, or are too expensive, or any other dismissive reasons, are part of the problem rather than part of the solution. Many people want the safety, security and convenience of good technologies, but not the responsibility of monitoring the impacts or implementing solutions. There are a lot of those people, but the hopeful note here is that they can become involved just as soon as they commit themselves to it. Changing from a “problem” person to a “solution” person begins with a change of mind. Supporting Technology Assessment will be part of that change.

What other kinds of environmental retrofits are consistent with sustainability? Too much product differentiation is based on stylistic considerations rather than functional attributes. This ranges all the way from homes to toothpaste. This kind of wasteful foolishness is neither necessary nor healthy. People who look for, buy and live in houses with the premise that “your home is your castle,” are pretending that the “royal prerogative” of bygone eras is their personal mantra. Housing accommodations should meet certain functional requirements (which many don’t), but appealing to vanity and conspicuous consumption is not one of them! The waste and narcissism in such lifestyles does not speak well of the practitioners.

Automobiles are another good example of foolish extravagance. The electric car should have been widely adopted years ago. The high speed and acceleration features are counter-productive and dangerous – road racing and road-rage are often the result. Automated roadways would eliminate much of these excesses, and more use of public transit would also be very helpful. Widespread food choices and preparation preferences are also unhealthy. Much of “fast food” has minimal nutrition and maximal habituation. Too much fat, sugar and salt, and not enough roughage, freshness or nutrients. Obesity is now a world-wide epidemic, based on the vain hope that “modern medicine” will enable good health but still permit dietary abuse.

All of the above have environmental impacts as well as personal consequences. But even the suggested solutions featured above, need their own assessment. What will be the impact on our electrical infrastructure, if many automobiles are having their batteries recharged overnight? We will need additional generating capacity, more robust network interconnectivity, and smarter load-shifting and load-shedding algorithms – it can be done, but it requires careful planning and management.
FUTURE RETROFITS

Regardless of the due diligence in assessing and evaluating proposals, prototypes and products in terms of what impacts they current cause, or are very likely to cause in the soon after deployment, some of the eventual impacts will not be anticipated. These impacts will *emerge* of the interactions between the products or systems being focused on, and other technologies, users and by-standers, and the natural environment. People may “invent” certain behaviors based on their extended experience with the product or system in question. Other technologies may be designed to interface with the innovations being considered, and this new interface may lead to results nobody did or could foresee.

The innovations may extend human capabilities, and that in turn, may lead to new forms of resource depletion or environmental pollution. Users may “discover” or “invent” ways of using a new product or system that were never intended, but have as a by-product something detrimental. What is at fault here? Mobile phone inventors and marketers never intended automobile drivers to use their phones while driving, thereby causing traffic accidents – this is just an instance of sequential effects that was not foreseen. But this happens often enough that Technology Assessment should try to forecast sequential effects.

Some of the scariest prospects are these sequential effects. Technology promoters often dismiss these possibilities as “scare tactics.” If technology assessment had forecast the impact of automobile on 20th century world civilization, car producers would have said there was no proof at all. If Technology Assessment had forecast the impact of aerial warfare on humanity, the Wright brothers would have disclaimed any responsibility. Yet mobile phones, automobiles and airplanes were instrumental in the effects produced.

When detrimental impacts are localized in their effects, the results may be tragic (Three Mile Island, Bhopal, tornados and floods, etc.), but others elsewhere can continue “business as usual.” But if genetic engineering or genetic medicine are applied to people, the results could affect all of humanity. Insurance companies already use family medical history as the basis for increasing premiums on those more prone to age-related illnesses and ailments. If genetic medicine offers greater immunity to those who can afford it, those who can’t will either pay considerably more for insurance, or be denied it altogether. If parents genetically engineer their children, then the selected superior traits could become the basis better education, jobs, leisure pursuits and social opportunities. Literally every activity people participate in could become a two-tiered (or more) basis for status or accessibility to certain services. What should Technology Assessment recommend about these possibilities?

Cognitive technology (artificial intelligence) has supposedly been growing by leaps and bounds in recent years. According to those claiming to be knowledgeable, human capabilities will be surpassed before mid-century (2050). In the process, more and more products will become “smart” – able to
monitor human behavior AND intervene in “our best interests!” Automated highways will control all vehicular navigation – speed, passing, stopping, entrance and egress from one roadway to another, etc. No more speeding, erratic driving, of other idiosyncratic preferences. If you don’t like the route the “car” has chosen, too bad! After all, the rate of traffic accidents has shown that the judgment of drivers is too unreliable to be trusted. What should Technology Assessment conclude about these options?

Information Technology has already started to represent “social memory” for certain kinds of events or processes. The “cloud” can store more and more. But over a century ago, Nietzsche advised us that being able to forget was as important as being able to remember. It’s not always an advantage to have every incident recorded for posterity. The lessons learned are important, but the on-going details may be burdensome. Such details may also be embarrassing, intimidating, even excruciating – rather than a corrective, they may an impediment to on-going action. Can Technology Assessment recall enough negative examples to recommend a balanced approach to memory management?

Nanotechnology is the furthest away of the “big four” in terms of possible detrimental impacts, but the most awesome regarding the scale of impacts likely (if its advocates are correct). Among the capabilities of “microscopic molecular manufacturing” it that of devising tiny “medical devices” to either circulate through the human body, OR lodge in a particular location in the body so as to be able to perform a specific function. Organs could be repaired, biological activities enhanced, or processes monitored. How about a device that monitors the functioning of your brain, and signals authorities whenever “suspicious” cognition patterns begin to form? There is nothing to worry about – if such patterns persist, your neural net will be so stimulated that such cognitive patterns will immediately be replaced, unconsciously of course. After all, we should all be thinking good thoughts! There are probably a thousand and one other biological processes that could use a little nanotechnology assistance. Pretty soon it might even be possible to live much of one’s life on auto-pilot! Is this the kind of future Technology Assessment should be concerned about?

Given human ingenuity, there are future impacts of technologies that most of us have not even dreamed about yet. This is, of course, very interesting, very creative, and very exciting. Enormous benefits could conceivably be “just around the corner” waiting for some new constellation of technological capabilities to “reveal themselves.” But, probabilistically speaking, most of these new possibilities will entail more detriments than benefits. Cognitive psychologists point out that what makes human life possible is the capability to “think ahead.” Most people however, seem to prefer a very short time horizon for this “anticipation function.” But throughout the modern era (from the Enlightenment onwards), using only this short time horizon has become more and more dangerous. If we don’t begin to foresee significantly further ahead, we may incur irreversible damage to ourselves and our environment. Technology Assessment is a social investment is an “assurance policy” so that we don’t undermine our very existence. If we keep shirking our responsibilities we will be like those who look the other way when people need help, so that by the time they need help themselves there is no one left to offer it.
Part Three
The Decision Process

Regarding Technology, there are two different kinds of decisions that have to be made:

(a) Decision about **whether** or not to conduct a Technology Assessment; and
(b) Decisions about **how** to conduct a Technology Assessment if the first decision is positive.

Both kinds of decisions need attention to implement the practice of Technology Assessment.

As well as recommending that modularity be adopted in Design and Deployment, advocates of this approach also favor a Modular Decision Process. Herbert Simon laid the groundwork for modularity in decision-making by suggesting that larger projects be decomposed into smaller assignments that would be more easily managed. This has turned out to be a productive suggestion, and has been widely adopted.

However, advocates of modularity have given considerably less attention to the mechanics of “actually deciding.” Such questions as **what is a decision**, and **how is decision-making performed** are usually consigned to practitioners. However, if modularity is such a useful approach, surely it can be applied here too! The advantage of modularity, which advocates never tire of trumpeting, is that it reduces complexity, and this leads to more manageable results. Can decision-making be modularized so that it is less complex, and therefore more manageable? Since “decisions” are human contrivances, it should indeed be possible to simplify them.

The way to begin this simplification process is by discarding the procedural complexities of “decision-making logic.” For decisions to be simple and effective, the process has to be pragmatic. Getting caught up in too many details, or spinning out too many scenarios, will just complicate the process all over again!

Another process that Herbert Simon pioneered, is actually the key to making modular decision-making work – this is the process of “chunking.” Regarding concepts, Simon proposed that concepts could be graded in terms of various degrees of inclusiveness or exclusiveness. “Furniture” is more inclusive than “chairs,” and “chairs” are more exclusive than “furniture.” All concepts could be placed on a scale with inclusiveness at one end and exclusiveness at the other, and users could range up and down the scale depending on their cognitive needs. He called this process of moving up and down a conceptual scale “chunking.”

In terms of the practice of Technology Assessment, “decisions” can be reduced to the following definition: **Choices** between alternative **solutions**, to identified **problems**, in light of prescribed **goals**. So “problems,” “goals,” “solutions,” and “choices,” would be the decision modules. Identifying the perceived problems, prescribing the feasible goals, reviewing alternative solutions, making effective choices, would be the tasks (functions) performed within each of the decision modules.¹

¹ Adapted from Paul Watzlawick, John Weakland & Richard Fisch, CHANGE, W.W. Norton, New York, 1974
DECISION META-RULES TO ENABLE TECHNOLOGY ASSESSMENT

<table>
<thead>
<tr>
<th>Identified Problems</th>
<th>Prescribed Goals</th>
<th>Alternative Solutions</th>
<th>Effective Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the challenge creating the problem, and how does it produce the problem?</td>
<td>What outcome will rectify or alleviate the problem in a cost-effective manner?</td>
<td>Are there different ways of accomplishing the goals, and what is the advantage of each?</td>
<td>What anticipated first-order effects do the available choices involve? Specify!</td>
</tr>
<tr>
<td>Is it a pseudo-problem (invented to justify or reject a technology)?</td>
<td>How can exaggerated expectations about the problem be managed?</td>
<td>What disadvantage(s) does each solution entail?</td>
<td>What anticipated second-order effects are likely? Specify!</td>
</tr>
<tr>
<td>Is it just an existential difficulty for which there is no cure or fix?</td>
<td>What will be acceptable measures of successful implementation?</td>
<td>Can trade-offs be made between advantages and disadvantages?</td>
<td>Do the anticipated benefits exceed the detriments? Specify!</td>
</tr>
</tbody>
</table>

One controversy about “pragmatic decision-making” is whether or not a fifth component, namely “results” (of the decision) should be added. Some decision “purists” claim that the “essence” of decision-making is strictly internal to the process, and results are an external concern. But for those who see the rationale for decision-making as the results that the decision produces, results are their primary focus. However there is a way of dealing with this issue that does not require choosing either alternative. The results of applying the choices made (or not applying the choices made), will raise further problems, in and of themselves! And in dealing with these further problemss, the decision-making process begins again.

One of the “virtues” of Modular Design and Modular Deployment, is that the process can be more flexible than complex and integrated design or deployment. This virtue applies to Modular Decisions as well. If we can identify “where” in the decision process a problem is located or a change is needed, then it is possible to retrofit the part of the process that needs attention. “But won’t there be implications of a change throughout the entire decision process?!” Of course there will be, BUT by identifying a primary locus for retrofitting, the implications can then be traced backward or forward from there, one module at a time. This makes the entire process eminently more manageable. And that is the rationale for modularity in the first place. This is not the advocacy of perfection, but just a way to get “a handle on” the process so we can see where action is needed, and what results are occurring.

Decisions occur in both Design and Deployment. By implication they will also occur in Technology Assessment. So the overview is this: (a) what challenges, questions or problems does a particular exercise of Technology Assessment raise – benefits, detriments, interactions, implications? (b) What goals do the Technology Assessors recommend for design and deployment – increase benefits, decrease detriments, enhance wellbeing, minimize disruption? (c) What solutions, suggestions or recommendations can/should Technology Assessors offer as a result of their assessment – research, reconfigre, redesign, recall? (d) What choices does a Technology Assessment imply when substantial change is suggested – regulations, concessions, trade-offs, negotiations?
If there isn’t “a problem” with a specific technology that is being assessed, then there is no need for retrofitting or whatever. However, the “no problem(s) whatsoever” situation is very unlikely to ever occur. The very fact that a particular aspect of a technology might result in a “no problem” judgment by some, might be the very reason that others would find the same aspect “very problematic indeed!” Fast Food may be to some peoples’ liking, but it engendered a Slow Food movement amongst others. The same kind of response has occurred to fast traffic, fast professional advice, fast dating, etc.

So, what is needed is a clarification of what (exactly) the problem consists of, what caused or is causing the problem, and how serious the problem is considered to be. Problems are often (usually?) misdiagnosed, and in logic a faulty premise leads to a faulty conclusion. One cause is the penchant to state the problem is vague terms – such as “I don’t like it,” “it doesn’t work very well.” Under these circumstances the Assessor must ask “what exactly don’t you like?” or “in what way exactly doesn’t it work?”

Misdiagnosis may happen the following way: if a problem occurs because of what some other person does (or doesn’t do), the problem may be misdiagnosed as a Procedural Problem, when in fact the person involved had the discretion to do otherwise. Alternatively, the problem may have been that the procedure itself left no room for discretion, but the person involved is “blamed” for the outcome. Metaphorically speaking, going in the wrong direction is unlikely to lead to the right destination. You can’t produce a changed effect until you target an initiating cause!

Pseudo-problems are “made up” to justify actions taken in situations where nothing “really” needs to be done. The lower the risk (probability of harm), and the higher the cost (per “unit” of effect), the less compelling is the need to solve a “problem.” Similarly, a pseudo-problem may be hypothesized as a “scare tactic” to steer the decision process away from a technology that actually has low or no likelihood of being either high risk or inordinately expensive.

Existential difficulties are sometimes (often?) treated as “problems” when there is no likelihood of being able to actually change the situation. If you live near a commercial centre (shopping plaza, super-store, etc.), there will likely be a lot of road traffic and little or nothing you can do about it (except move). If you are at a party, there will likely be a lot of conversation and noise, and little or nothing you can do about it (except leave!). If you invest your money in speculative “securities” there will be high risk of large losses, and there is nothing you can do about it (except cash out). At times like this, recall the saying, “You can’t have your cake and eat it too!”

The problem with technology is that its suppliers often (usually) overpromise on the benefits, and ignore or deny the detriments. And as the ambitions of these suppliers become greater, so do the accompanying risks. The fact that such people “mean well” doesn’t for a moment eliminate or reduce their culpability. On the other hand, the eagerness with which customers accept the supplier rationales AND then adopt patterns of irresponsible and/or dangerous use, speaks to their persistent gullibility. The problem for Assessment is that in the suppliers’ eagerness to make money, and the customers’ eagerness to “try the new toys,” by the time problems are fully delineated the technology may be widely deployed and very difficult to recall or retrofit.
INSTIGATING CHALLENGES

Throughout the majority of humanity’s history, the predominant challenges people faced originated in nature. The sedentary agriculture/human settlements phase only began a few thousand years ago. By the time of the Modern Era (dating from the Enlightenment), most of the challenges had changed from natural ones to social ones. A modernized, mechanized habitat has far more social risks than natural risks.\(^1\) Storms and floods still do wreak havoc on people and their property. However, far more damage and death are caused by weapons use, careless driving, bad investments, dangerous lifestyles, intermittent warfare, industrial accidents, and unwise drug use, etc. Technology Assessment is a technique designed to assess and evaluate dangerous situations that result from the interactions of people, technologies and the environment.

How do problems occur in the first place? Some circumstance or situation is interpreted as an impediment for an intended action. That intended action may involve change, or preserving something the way it is. Whichever, if the challenge is “accepted” then action of some kind is likely to follow. Complicating the simple problem is the occurrence of opposing individuals or groups who interpret the same situation as involving two opposite challenges – some want to change the situation, others want to preserve the situation!

Whatever the challenge, or the motivation, the first thing to clarify is what people “understand” the problem to be, and what questions are implied by the problem. People who experience a challenge, which raises questions in their minds, often assume that one or both of these cognitive outcomes are “obvious!” The most that can be said for this contention is that for “true believers” these conclusions may be obvious (although not necessarily), but in the case of others it is often NOT obvious at all.\(^2\)

So, what really happened (or didn’t happen) to precipitate the challenge? There are often two implicit assumptions behind whatever answer is given to the question of the origins of the challenge. The one assumption is that something or someone is “responsible” for the occurrence of the challenge, whether that is praise-worthy of blame-worthy. The second assumption is that the appropriate response to the challenge includes “setting the record straight” about the precipitating causes. Someone or something is either “commendable” or “at fault” for what happened or is happening, and that should be publicly acknowledged.

Is “the problem” that of responding to the challenge, or responding to the culpability? More often than not the primary motivation is based on responding to the culpability. Those so motivated want to “make somebody pay” or “gain the glory.” When this is the case, “the questions” become “how to deal with the challenge” AND “how to hold those responsible, accountable?”

How should the Technology Assessment process deal with this situation? If, as previously mentioned, setting the proper question takes us more than half-way to the appropriate answer, then “dealing with the challenge,” or “dealing with the challenge AND the responsibility,” will take the results in significantly different directions. Since the Assessment will deal with participants some of whom will want only the challenge considered, and others who will want motivation included as well, both factors should be included, BUT treated separately (the subject-matter should be modularized too!). The “challenge only” section(s) will deal with how to respond effectively to the challenge. The “motivation + challenge” section(s) will deal with “why” as well as “how” the challenge arose and why and how to respond.

What other questions could also be raised? One important preliminary question could be, “are the consequences of this challenge significant enough or important enough to merit a formal, full-fledged assessment? If a home-owner opposes the building of garage or toolshed in his neighbor’s backyard, is this a Technology Assessment issue? If a home-owner across the street opposes the widening of the roadway to accommodate a growing volume of traffic, is this a Technology Assessment issue? Answer: neither is likely to qualify. Does a new line of car imports with a reputedly inferior braking system qualify for a Technology Assessment? Do the plans for a toxic waste processing plant at the end of the street merit a Technology Assessment? Answer: these last two definitely qualify for Technology Assessment.

How long will a Technology Assessment take to complete? How much will it cost? What types of professionals should be included in the Assessment and writing of the report? Will the Assessment team have powers of subpoena? Who will pay for the Assessment? Will the recommendations of the Assessment report be binding? Will anyone from the Assessment team be available to assist in implementing the recommendations? Will the ongoing performance of the technology be monitored? Will any newly emerging impacts be flagged? Will the relevant members from the original Assessment team be available to assess the newly emerging impacts, and make further recommendations about how to deal with them? These are the questions that are “internal” to the Assessment process.

There are also questions “external” to the Assessment. Are their “political implications” to the question of whether to assess (or not to assess) any particular technology? Will participants from the general public receive any remuneration for their service? What course of action will be taken if and when there is a direct refusal to implement measures from the Technology Assessment Report? What if the Technology Assessment report recommendations become as controversial as the technology in question? All of the above questions are likely to be raised at one time or another, and most of them in some Assessment cases.

From the “decision point of view,” clarifying the challenge and the questions it raises, will get the process off to a good start. Later, as answers, reasons and choices are considered, it may be necessary to return to the questions for further elaboration – the initial work here should help there too.
QUESTIONS

Idealists contend that “questions” are more important than answers. Pragmatists contend that “answers” are more important than questions. As a Pragmatic Idealist, I contend that both are important, and that the whole is more than the sum of its parts.

Creative Thinker Edward De Bono is a great advocate of good questions.¹ But I, like him, appreciate the questions for the opportunity they give to provide good answers. Other thoughtful analysts often claim that “defining a question properly takes you more than half-way to the correct answer.” If only it were a matter of “objective observations and rigorous responses” – but alas, it is not!

Both questions and answers depend, in part or in whole, on the interests of those doing the questioning and answering. In other words, “acceptability” (or the lack thereof) plays just as big a role (if not bigger), as “objectivity.” This can be illustrated very easily by two opposing slogans: (1) Seeing is believing; and (2) Believing is seeing. Human beings are prone to both, even the SAME human beings! Just as we should accurately report what we observe, we should recognize the way our perspectives shape our observations.

When it comes to defining questions based on encountering challenges, we are considering a “content and context” situation.² What we have learned from a wide variety of these situations, is that context is just as important as content. The challenge is the context. The challenge can be positively evaluated as an opportunity, or negatively evaluated as a calamity. The kind of question an opportunity invites is: how can this challenge be handled to produce a good result? The kind of question a calamity invites is: what can be done to make this challenge go away?

If the majority in a community regard a challenge they face as an opportunity, they could probably cooperate in posing a question that could lead, one way or another to a solution. If the majority in a community regard a challenge they face as a calamity, they could probably cooperate in posing a question they hope will lead, one way or another, to the elimination of the challenge. If the community is about evenly divided, it is going to be harder to achieve either a solution OR the elimination of the challenge, because there are two questions in contention. So, estimating the nature of the challenge, and the various community views about that challenge, are both important in defining the question(s) to be asked.

PSEUDO-PROBLEMS

The modern world has encouraged considerable individuation and narcissism amongst the general public. The more people exercise their idiosyncrasies, the more they are likely to express such individuality through patterns of consumption, at least so marketers believe. One of the results however, is that consumers develop exaggerated expectations about the safety, security, convenience and performance capabilities of technologies. When a user “clicks” on the “close” or “exit” button on a computer screen, the “scene on screen” changes immediately and significantly. This “ease of use” and “instantaneous results” begins to create expectations that other domains of life should operate similarly.

“Why can’t we just ‘click away’ whoever or whatever displeases us?!” With this psychology, anything and everything that is not “to our liking” become problematic. The morality of “exceptionalism” fits very conveniently into this worldview. “Of course other people have to obey the rules, but in ‘my’ case surely an exception is allowed?!” Where the results of all of this are innocuous, it doesn’t matter anyway. But where there is technological risk, the stakes quickly escalate to prospects of danger and death.

The results, before reaching the level of danger and death, is that technology suppliers are facing what public policy providers have experienced for at least a generation – demand overload. Individualized stylization of the size, shape and color of consumer products permits minute differentiation in consumption patterns. People who are willing to dye their hair almost any color are also willing to paint the rooms and customize their “personalized color ensemble” any which way it suits them. They may need a chartreuse computer housing and mobile phone case “because that is their color!” And if they can’t find it, THAT’S a problem.

Technology producers play the same game. They “dream up” products to entice every sensibility a person can experience. But what if consumers like their chartreuse mobile phone so much that they use it when driving, hence endangering both themselves, other passengers in their vehicles, and other drivers? What if marketing “discovers” that a chartreuse set of mobile phone, computer, shoes and ear-rings are sure to sell very well if they are properly marketed? Is the absence of matching chartreuse computers, phones, shoes and ear-rings, a “real problem” or a pseudo-problem?

As well as individually defined pseudo-problems, there are collectively defined ones. Both companies and social groups have them. For many religious believers, of whatever faith or denomination, the “real problem” in the world is the number of infidels or atheists. “If only everyone were to become converted to (their preferred option), there would be no more problems in the world.” But since there are versions of this view in every faith and denomination, there is little prospect on this route for accommodation. So many believers
become “passive-aggressive” in their dealings with other “problems.” How does this relate to technology? Such believers are often willing to use many technologies to further their cause, regardless of any accompanying detriments, because their primary “cause” trumps all other considerations.

All of this raises the question of “what criteria are appropriate for distinguishing between real problems and pseudo-problems?” Many people with personal or group concerns will quite likely regard their “problem identification” as authentic. The answer is “implications and consequences” – if a particular “problem” does not jeopardize safety, impair functioning, or entail inordinate costs (i.e. does not increase risks), then from a Technology Assessment point of view, it is a trivial problem or pseudo-problem. In that case, the more effective coping strategies are either to ignore, avoid, or adjust, something most people do on a continuous basis anyway.

Wise as the foregoing strategies are however, such suggestions will not necessarily sit well with those who have made a strong commitment to the solution to a particular pseudo-problem. Those with a “chartreuse fixation” may continue to agitate for their preferences. One thing that Technology Assessors could do when dealing with technological pseudo-problems, is to take some time to remind their audience that living in a democratic society does involve compromise, and no one ever gets their way all the time. There may be other technological issues that the disgruntled group is OK with, but someone, somewhere else is not. Unless a widespread social movement can be organized to support a solution to a pseudo-problem, personal coping is likely the only viable strategy.

What all of this implies is the need for a sense of “proportionality.” Pseudo-problems arise out of the penchant of some to “turn mole-hills into mountains.” If such practices are harmless, and many are, it doesn’t matter. But when such issues start to grow to occupy a disproportionately large section of the “social problem space,” that is the time to “step back” and look at “the bigger picture.” The rationale for Technology Assessment in the first place (and democracy as well), is the larger impact of certain activities or lack of activities.

There is only a limited amount of time and effort to devote to “problem solving.” Hence, it is necessary to determine if a perceived problem is worth the time and effort needed to solve it, given the limited attention span and resources available. That is why risk is the fundamental criteria for impact assessment. If safety, functioning or cost are at issue, real harm is possible and preventative or ameliorative actions are necessary. If however, the issue is just one of personal preference, casual habit or aesthetic expression, this is when the virtues of tolerance are appropriate. No real harm will come from not having your chartreuse personal accessories, and Technology Assessors can be forgiven for focusing on preventing physical injuries or environmental pollution rather than recommending color coordination of consumer products.
DIFFICULTIES

There are PROBLEMS, and there are Pseudo-problems, and then there are just existential difficulties. When people try to turn existential difficulties into problems, the solutions they propose (and sometimes impose) can become the actual problems.

Aging is a good example of an “existential difficulty.” With each moment, minute, hour, day, week, month and year that a person lives, they become older (i.e. they “age”). One of the hot topics in biotechnology these days is whether anything can be done about this situation. What exactly does that mean? Futurist Ray Kurzweil has charted the historical progress of medical research, and then extrapolated the trends into the future. On the basis of these trends, he claims that the basis for immortality will be discovered within the foreseeable future. That is Ray Kurzweil’s answer to what we can do about aging.

However, strictly speaking, that discovery will NOT prevent aging! If such a discovery were made and applied, those immortals would still be aging. What they would not be experiencing would be “progressive decrepitude,” the successive decline in biological functioning. But would these immortals be any happier, more fulfilled, wiser, possessing genuine wellbeing? That would depend on a host of other considerations, including psychology, economics, sociology, politics, and just plain luck. Technology might be able to extend peoples’ lifespan longer, perhaps even indefinitely, but that would be no guarantee in itself that those involved would find the experience worthwhile.

Perhaps the biotechnology that promised immortality might have other serious side-effects that would give society pause to consider before deploying it. Would immortals become a global elite, and everyone else just an “ordinary human being?” What if only certain human bio-types could make use of this technology. Perhaps blood type, or another genetic anomaly would restrict its application. Would immortals achieve the status of demi-gods, as would befit ancient mythology? At the moment these questions are only speculative, but if the technology becomes a reality, these questions and many more will become critical social and political issues.

Human diversity is another condition that some people find very difficult to deal with. This particular existential difficulty has been treated “problematically” for a very long time. One of the most prevalent “solutions” to the “problem of diversity” has been the combination of culture and ideology. [But is this “technology” – yes it is. Technology includes both techniques as well as tools, and cultures and ideologies are techniques.]

Cultures and ideologies are techniques of “social control.” The concept is to condition everyone in a group to behave in similar enough ways so that group solidarity is created
through acceptance and practice of prevailing norms, and deviance is readily identifiable and potentially correctable. The result has been in-group tolerance of out-group intolerance. The questions these practices always raise are, how much conformity is “required” and how much “diversity” is allowable?

In agrarian societies, the norm was “more conformity and less diversity.” With modernity and industrialization, permissible diversity began to increase. In so-called “post-modern societies” the range of alternative lifestyles has become so diverse that some social analysts are now beginning to ask if the very basis of social solidarity itself is now eroding.

Authoritarian societies were generally more conformist, whereas democratic societies were generally more diverse. Is there an appropriate or functional balance below or above which diversity or conformity should not go? What about those who either want more or less diversity, more or less conformity? THIS is an existential difficulty which it is VERY tricky to deal with!

Fundamentalist Muslims usually opt for more conformity, so their religion is both a cultural and a political technique for social control. Authoritarian ideologies, such as Communism, Fascism and Traditionalism often opt for the same thing, but by employing secular rather than sacred rationales. The many forms of democracy usually lean towards diversity.

As a general rule, technology usually enables wider degrees of diversity, but still within limits. However, these limited degrees of diversity are still far too broad for authoritarian temperaments. So, in “modernizing” societies, there are constant campaigns, one advocating more diversity, the other advocating more conformity. One way this has been party resolved is through the separation of private and public spheres. More diversity is usually possible and practiced in private, whereas more conformity is usually necessary and practiced in public. In many cases however, privacy is used to conceal what are regarded as taboo behaviors in public. Drug-use, domestic violence, petty theft, etc. are practiced in private in the belief that perpetrators can “get away with it.”

Existential difficulties won’t go away, and many people will continue to try and “problematicize” them so that they can apply their preferred solutions. Technology Assessment should steer clear of these issues unless either the degree of conformity or diversity become dysfunctional (begin to adversely impact safety, security or the cost of social operations). As a personal strategy, “public conformity and private discretion” has the advantage of providing access to technological conveniences while preserving a considerable degree of private latitude. It’s not perfect, but then we shouldn’t expect utopia or heaven on earth, and more technology won’t get us any closer.
Once the problem has been identified, the task becomes to prescribe the goals that will alleviate the problem. Once again, the challenge is to be specific rather than vague. Far too often the projected situation where the goals have been achieved and the problem is solved, is described in “good feelings” terms rather than demonstrable objectives. Such good feelings, if and when they occur, will be welcomed, but they do not represent something we can do or see accomplished.

Hence, one way of beginning the specification of goals, is to spell out exactly how behavior will change so that the problem is eliminated. If the problem is “too much” of something, what can be done to eliminate some of it? If the problem is “not enough” of something, what can be done to get more of it? When the goals are accomplished, just the right amount of that something will be present.

On the other hand, perhaps the problem consists in something that someone is doing. In a case like that, when the person does less of that problematic thing, or desists entirely, the problem will be solved. If the problem is that a person, or persons are not doing enough of some kind of behavior, the goals will be to induce them to do more of it. Once the frequency of the desired behavior is at an acceptable level, then the problem will be solved.

Depending on the nature of the problem, there could be a few factors needing change, or many of them. In terms of goals, the more that achieving them requires, the more time, effort and money will likely be involved in their accomplishment. But usually you don’t have “forever” to solve a problem, or a limitless budget. Once this recognition is reached, the “goal” for goals is to focus on the minimum “have-to-have” factors rather than a broad wish-list.

The outcome is to specify everything that functionally needs to be there – everything that will actually eliminate the problem. That is the project check-list of goals – every item on it needs to be there for the problem to be solved, nothing is on it that doesn’t need to be there for the problem to be solved. At a few points, review the list so far, and perform a reality test – given everything added so far, does it turn out that, contrary to expectations, either some items are redundant, or the importance of some items not added is now seen to have been overlooked.

Do all of the check-list goals REALLY need to be addressed to solve the problem, or is wishful thinking getting in the way of necessity? It would be nice to piggy-back a “favorite item” on such a list if the budget would cover it, but the more factors involved, the greater is the challenge in accomplishing them, and the more likely are unpleasant surprises. This shouldn’t be a “pissing contest” but rather a realistic assessment of performance requirements!
COST-EFFECTIVENESS

Can the prescribed goal be accomplished in a cost-effective manner? If not, that particular goal (or some part thereof) is not feasible. If none of the goals can be so accomplished, very likely this is an “existential difficulty” rather than a problem. A considerable amount of time and effort are usually devoted to “thinking through” goals, and cost-effectiveness should be one of the first considerations.

The estimation of costs crucially depends on the importance of the goal in question. Does the goal possess a “nice to have” or a “have to have” quality? Could the problem be solved without the accomplishment of the goal? If no, then either sufficient funds will be allocated, or the problem will continue. If so, then an alternative goal that is cost-effective can be substituted.

Perhaps a slightly, or a very different version would be more feasible? Perhaps the timing of the implementation could reduce costs? Perhaps a goal that had not been considered, or has been previously rejected, if it were more cost-effective, could replace a more expensive one? Is it known for sure that certain goals are needed, or that certain costs are prohibitive? Is there some change in the way the goal is defined, or the way it is implemented that could reduce costs?

At this point, there are two perennial challenges to consider. One is the prospect of under-funding. Budgets are often set with no apparent recognition of the context within which the money will be spent. Arbitrary limits are imposed reflecting prevailing policy, or previous experience, or the personal preference of the signing authority. In such cases, is there any likelihood that presenting the “larger picture” will be convincing enough to get the shortfall of funds rectified, and thereby proceed with implementing the goal(s)? Is it worth a try?!

The other challenge is over-estimation, of either the value of the prospective goal, or of the likely costs of implementation. Developing or deploying technology usually involves considerable amounts of associated uncertainty. Those focusing on the problem tend to prioritize its solution. Those paying the bills may see the situation in wider, or narrower, or different terms. In the larger context, the problem may be considered minor, of the goal may be considered impractical or unacceptable. Is there any validity to such views?!

Against the costs of implementing the goal(s), what should also be considered is the benefits of solving the problem. If the value of benefits derived from experiencing the goal(s) are sufficient to cover the costs of implementing them, then this project is a good social investment. In these circumstances the question becomes one of how the costs and benefits will be allocated – will the benefits be sold or subsidized?
The costs of design and deployment, however large or small, and however financed and recovered, are still only part of the costs involved. Customers will not only pay for the goals implemented, but consumers and those affected will also pay user costs and related expenses. Automobiles not only have a purchase price, they also have ongoing fuel and other servicing costs (maintenance, repairs, licenses, etc.). Roads have to be built and maintained. Traffic lights and signs are required. Cities are built around road networks. An automobile manufacturing and repair industry becomes a major component of the economy. Ditto communications, entertainment, food production and distribution, education, etc.

In the process of all this product design, deployment, and use, resources are used, patterns of living continuously change, both benefits and detriments result from these processes, and eventually the products wear out or obsolesce and are discarded as pollution or garbage. Every step in every process for every product has these costs, but who is going the forensic accounting for these processes? If all the costs and benefits are added up and compared, are we really getting “value for our money?”

The costs on the design/production/deployment side are offset by profits, tax expenditures, R&D grants, etc. But the costs on the acquisition/adjustment/disruption side are covered by the recipients. What this amounts to, is that both the producers’ costs AND the consumers’ costs are covered by the public. There are occasional exceptions on each side, but by and large the public pays “both coming and going!” Since governments usually claim to be “the government of all the people,” why don’t governments take greater care to make sure that the burden of costs is reflected in the imposition of costs?

Conventional Political Economy usually excuses this situation by “explaining” that “this is the way the market works.” However, there was a time when child labor, hazardous working conditions, extreme pollution and “buyer beware” were also excused with the same explanation. Costs should be borne by those who create them, if cost-effectiveness is to be considered a credible rationale.

So, Technology Assessment should evaluate the size and distribution of the costs accompanying design and deployment of technologies. Do the expenditures on design and deployment result in tools and techniques which will provide “value for money” for consumers and users? Do the problems which are reputedly being addressed warrant the expense being incurred, by producers AND consumers? Are the costs of rectifying or alleviating the detriments from applying these new tools and techniques actually worth the resulting benefits to the producers AND consumers? According to advertising and other promotional material, the answer to this question should be, and obviously is, yes. Some accountability is needed on this issue. Technology Assessment can be part of that accountability process.
EXPECTATIONS

Specifying goals almost invariably encounters the condition of “exaggerated expectations,” whether at the personal or the social levels. The various forms of promotion in the mass media are specifically formulated to deal with this condition. In most cases however, these exaggerated expectations are encouraged rather than discouraged. Since expectations are one of the most often-used cognitive techniques for “planning the future,” further encouragement of an already-existing tendency usually results in completely unrealistic demands regarding “delivery on those expectations.”

When the prospect for slight improvement (on almost anything we have or do) is advertised as if “everything will change (for the better),” there is almost no chance whatsoever that such promises will be fulfilled. After the “high” generated by the alluded “state of perfection” that accompanies the reception of such promotions, the “let-down” that comes in the wake of the disappointing actual performance, leads almost invariably to disillusionment, often of a profound nature. In the process, the trust that was built on exaggerated expectations, is replaced with the distrust buried beneath disillusionment. Consider the impact on public culture. Politicians often make exaggerated promises, many of which are not fulfilled. The result has been that the role of politician is now regarded with the same suspicion and contempt that was formerly reserved only for “used-car salesmen!”

Many Professionals have suffered the same fate. The advertisements of Criminal and Personal Injury lawyers imply that they will always win your case and provide you with a great settlement. But in practice, alas, they refuse some cases, lose some cases, and perform unsatisfactorily on others. And so we have the term “shyster lawyers!” Doctors are experiencing similar mistrust. Too often they prescribe over-priced medications that are not particularly effective, but for which the manufacturers provide them with “special considerations.” In the case of physicians, the one problem that seems to lie behind many specific complaints, is a lack of “due diligence” regarding diagnosis, prescription, and follow-up. It turns out that the image of “the caring doctor” (the Marcus Welby type) has been “over-sold!” A few bad experiences and the word “gets around” and mistrust sets in.

How has this cycle of exaggeration > trust > disillusionment > mistrust become so deeply entrenched? Some of the people who use exaggeration to promote their wares, actually initially seem to believe their own idealized rhetoric. This however is rare, and almost never persists beyond the first few cycles. In the vast majority of the cases, exaggeration is used for the “good and simple reason” that the public “eats it up!”

The advent of the Enlightenment movement at the beginning of the modern era was supposed to change that cycle. “The light of knowledge” was suddenly proclaimed as the means of a better world and an improved humanity. Idealist proponents have been updating those promises ever since, based on the accumulating store of knowledge and the results of technological application. Behind all the specific promises was the premise that “Ye shall know the truth, and the truth shall make you free.” Over the intervening time, the application of science and technology did, in fact, free larger and larger proportions of humanity from hard physical labor. In the process, the standard of living, and the average lifespan were also increased for most of those in “modern societies.”

These changes have been real and important. However, some other things do not seem to have changed much at all. Behind the many improvement promises is the assumption that the majority of the public would
adopt an “enlightened outlook.” The chief instrument in this process was to be widespread public education. The method chosen was to teach children to read and write. Although not without its problems, this system of education was implemented and has succeeded remarkably well. Literacy and numeracy are widely prevalent in modern societies. However, a couple of essential forms of literacy that would be needed to complete the enlightenment process, has not, by and large, been taught.

Knowledge Literacy and Media Literacy are notably lacking amongst the public. Knowledge Literacy is the capability to “take apart” (deconstruct) the various components of a knowledge claim or statement so that it is possible to evaluate its relevance and veracity. Media Literacy is the capability to “take apart” (deconstruct) the various components of a media presentation so that it is possible to evaluate its rhetoric, relevance and veracity. Because most of the public does not have either of these literacy capabilities, they are extremely gullible to Knowledge claims and Media presentations.

Therefore, promotional advertising about new technologies are designed for the gullible. People don’t have the Media Smarts to discern the exaggerated claims being made. Not do they have the Knowledge Smarts to see the prospects for detriments as well as benefits. Furthermore, the new tools and techniques are increasingly designed to actually discourage thinking. “The laundry cap [on a container of laundry detergent] if a perfect example that is exquisitely adapted for one task, which is to make us stupid. I call objects of this type deceptors. Once you start to look around, you can find them everywhere….Absent conscious guidance, cultural evolution will produce an environment that is more hostile to human rationality. We will wind up with an environment that is increasingly full of deceptors.”

So, producers and promoters of new technologies are working together to stupefy us! And their tools and techniques are designed to deceive us about how they work, and how they don’t work. Regrettably, psychological research has also shown that most people have six irrational glitches in their thinking:  

1. Optimism Bias – the belief that “everything will be O.K.
2. Myside Bias – self-serving attitude that ‘I am an exception’
3. Frames & Anchors – fancy rhetoric and spurious examples trumps good analysis
4. Belief Bias – rigging the evidence to support one’s own perspective
5. Loss Aversion – catastrophizing the prospect of loss
6. Probable misunderstanding – hoping for an occurrence does not increase its likelihood

These disclosures entail a dilemma for the task of specifying goals for Technology Assessment. Technology producers and promoters often see it to their advantage to exaggerate the promise of technology, AND design the tools and techniques so they discourage user thinking. Consumers are psychologically inclined to accept such misrepresentations, AND dismiss any concerns or enquiries about the new gizmos until they have been widely deployed and emerging detrimental impacts have caused considerable human and environmental harm. This is exaggerated producer expectations reinforcing exaggerated consumer expectations! Hence, the single most important goal of Technology Assessors is to specify why both producers and consumers should agree to a more realistic evaluation of new technologies before too much damage is done through irreversible impacts. (Hint – risks are growing geometrically as the number of technologies is growing arithmetically.)

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ACCOMPLISHMENT

What will be acceptable measures of successful goal implementation, and how will successful goal implementation be accomplished? In a nutshell, the social pathology of deceptor technologies and exaggerated expectations must be seen for the delusions they are, so they can be replaced with responsible tool and technique designs, knowledgeable technology assessments, and informed consumer choices.

Since the effectiveness of a prescription depends on the correctness of the diagnosis on which it is based (because the use of a flawed premise leads to a false conclusion), we should start with an estimate of the seriousness of the presence of deceptor technologies.1 There three aspects of these miscreants:

(a) Accumulation – the longer deceptor technologies have been deployed, the more difficult it is to recall or retrofit them; instead they accumulate and become accepted as “the way things are”

(b) Contagion – they each set a “bad example” and through the social process of imitation, additional products and forms of functionality are similarly corrupted

(c) Promotion – producers use deceptor technologies as “money machines” to increase revenues, and this spreads their presence and their problems even further

A considerable proportion of innovations turn out to embody additional ways to perpetuate deception regarding the conditions of functionality. These conditions are analogous to a conspiracy of the blind leading the blind, toward a dangerous precipice.

In conjunction with “technologies of deceit,” we should also evaluate “mental laziness.” Historian James F. Welles traces the prevalence of stupidity to “the refusal to learn” – it’s not just the absence of knowledge, it’s the refusal to exert the mental effort necessary to acquire and apply the knowledge.2 To summarize, many consumers have a tendency to avoid learning about “the big picture” as much as possible, and producers build on and reinforce that tendency because they see it as the easiest road to financial success.

Under these conditions, perhaps the best place to start is to recall a rallying cry from the sixties: if you are not part of the solution, you are part of the problem! But with such a pervasive and entrenched problem, what goals can solve it, and how can they be implemented? At this point, another piece of new management wisdom (lessons learned) will come in handy. Larger, more distant goals are the results toward which we aim, but to actually accomplish them requires a sequence of proximate objectives that can actually be implemented, measured, and evaluated. Larger goals are that will (hopefully) be accomplished eventually (i.e., a cleaner environment, a

1 Adapted from Joseph Heath, ENLIGHTENMENT 2.0., HarperCollins, Toronto, 2014

2 James F. Welles, EXPLAINING STUPIDITY, Mount Pleasant Press, Orient, NY, 1988
safer workplace, more secure social infrastructure facilities, etc.), they are outcomes, not actionables. It is however, possible to actually work on the proximate objectives (i.e., recycling arrangements, safety procedures training, infrastructure facility resiliency through redundancy design, etc.)

Professor Paul C. Light has spent many years studying how such goals are implemented. What his studies show is that there are four types of contributions to social change, made by people who take on four different roles and responsibilities. Social Safe-Keepers are those who preserve and enhance previous gains – they will pitch in to assure that when these latest goals and objectives are accomplished, they won’t be reversed shortly thereafter, but will continue in effect and hence provide the benefits for which they were introduced.

Social Explorers study social trends and impacts, and identify problems either before or early on in their development. It is their documentation that demonstrates that something will need concerted attention, either immediately or in the foreseeable future. Without the kinds of studies Social Explorers do, it is all too easy to dismiss concerns and complaints as just nostalgia or grousing. Social Entrepreneurs and those who actually contrive solutions for the problems identified. Almost invariably they will propose a range of solutions rather than just one – some may be reformist, others more radical. To be workable however, such solutions need a coalition of supporters that includes policy-makers and those impacted.

Social Advocates actually take on the job of social or political mobilization. The organize activists so that tasks and responsibilities are shared and efforts are coordinated. They also help keep up morale by looking for the successes in the accomplishment of objectives, and celebrating each achievement as a victory. There will, of course, be feedback between those in the four roles, so that any lessons learned can be shared for the benefit of all.

Getting society to accept the practice of Technology Assessment will be a significant social change. The biggest challenge awaits the Social Advocates. They must make a case that is persuasive enough to inspire an important cross-section of the population to try something new. Framing such an argument will be a considerable exercise in rhetoric. A successful approach will likely be based on finding “common ground” within social diversity, inspired in no small part by the recognition that the kind of social and environmental impacts the new technologies will bring will place everyone at risk, regardless of class, race, ethnicity, gender, or geographical location. In this respect, technology really is “the great equalizer,” but this is the equality of universal risk rather than benefits. This is not what the Enlightenment promised, but it is the situation we now face.

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3 Paul C. Light, DRIVING SOCIAL CHANGE, John Wiley & Sons, Hoboken, 2011

Chapter # 10
SOLUTIONS

To reiterate, as the terms are used here, the “solution” is distinct from the “goal.” The goal represents the “new state of affairs” of the process of social change. The solution(s) are the various ways of getting to the goal, or getting the goal accomplished. It often happens that proponents of change also have a preferred way of accomplishing that change. To them a particular approach may seem “obvious” or superior to any of the other acknowledged alternatives.

In some cases the combination of an identified problem and a preferred solution may be so strong, that no other alternatives are even considered, and any attempt to interject an alternative is summarily rejected. In other cases, agreement about the importance of a goal is contingent on employing a particular method to implement that goal. If the method is questioned, this can throw into doubt the whole commitment to pursuing the goal.

Both of these situations can be described as proposals with “hidden agendas.” The pragmatic way to approach a goal and its accomplishment, is to firmly commit to a strategy (the policy and the measures of success), but to be flexible on the tactics (how and when to implement the goal.) This is also recognized as the major lesson learned from entrepreneurial experience. When there is a strong commitment to particular tactics, there is indeed a hidden agenda, and any such proposals should be treated in a very wary way.

Based upon both previous experience and realistic expectations, those committed to goals should be willing to acknowledge a variety of possible solutions, all of which can be narrowed down to the most feasible few, so that alternatives can be evaluated on their merits. What might be the most salient considerations that can generate alternatives?

Some methods of accomplishment might be considerably more expensive than others. Are the more expensive alternatives over-priced? Are the less expensive alternatives qualitatively inferior? Do some methods of implementation take considerably longer than others to accomplish? Will the shorter methods enable the required steps to all be completed? Are there deadlines that are inflexible, and have to be met?

Are some of the proposed methods clearly understood, and have practitioners who are readily accomplished at application? Are other of the methods entirely or substantially new, with a steep learning curve before anyone in the project can gain proficiency? Will some methods quickly gain approval from the project sponsors because they are familiar with the procedures? Will other methods require considerable persuasion before project sponsors will accept them?

Insofar as any or all of these issues are raised, or other ones of a similar nature, the prospects for any particular method should be thoroughly reviewed so that the implications of each solution are anticipated enough to give an appreciation of what will likely be the implications of alternative solutions. Technology Assessment particularly needs this kind of review, because in the past some of the “alternatives” that were proposed for particular designs or deployments, were discovered, after thorough reviews, to imply even more serious impacts than the methods they were supposed to replace. So, in the words of that old maxim, it would have been “out of the frying pan, into the fire!” Such outcomes should be avoided.
ADVANTAGES

The rationale for considering various alternative solutions, is that each of them may provide different kinds or amounts of benefit for their users. The place to start assessing the benefits of alternate solutions, is to recognize (and acknowledge) that such benefits may accrue to different individuals and/or groups who will be using the technology. The designers may aspire to “dazzle” producers and/or consumers with their creativity. This could lead to departures from conventional technology configurations which may (or may not) suit the demands of producers or consumers.

In such cases, what should be guarded against is the mantra of “novelty for the sake of creating a good impression.” If a change in design produces more functionality, safety or security for the consumer, and/or less production time or costs for the producers, with no discernable detriments, the new design could be worthwhile. The criterion should be “superior performance” if design changes are proposed. Every parameter which is altered by the new design should be tested to assure the same or better performance.

What should then be assessed is how the proposed superior performance is going to be achieved. For instance, will production of the newly designed technology require less person-hours during production, or entail fewer or different responsibilities in the production process. Perhaps the new design is simpler than the previous design, or requires less material. In such cases prototypes should be assessed regarding performance, so that fewer inputs do not result in less useful or detrimental outputs.

Does the new design alter the time frame within which performance occurs? Can production be completed in shorter time? Does the conjunction of fewer resources and less production time require more, less, or different production coordination arrangements or techniques? If new production machinery is needed, that may require operator training, and new production scheduling.

Producers usually have the inclination to look for solutions that reduce their production requirements. Here too there can be problems if the reductions they seek (fewer inputs of resources, person-hours, or R&D provisions) only result in “improvements” rather than users. As with designers, the criteria for any solution should be “superior performance” rather than simply lower costs.

From the consumers and users points of view, neither lower cost nor novelty are acceptable if the result will be less necessary functionality, safety or security. IF necessary functionality, safety and security are maintained or improved, then the conditions and consequences of use should be considered in some detail.
Will the newly designed technology require some training to use proficiently? Will the newly designed technology result in simpler operating procedures? Will the processes it performs require less time to complete? Will the new design be more “user-friendly,” enabling users to control operations more effectively? Will the new design be safer to use, and/or be less likely to allow malevolent tampering (i.e. more secure)?

Will any control panels or instruments be ergonomically designed so that performance readings and/or control variables are readily identified and their operations “intuitively based.” The “obvious” point to these latter questions is that the major advantages of new designs should accrue to the users – the advantages are not substantial and obvious to users, there is likely a “hidden agenda” whereby any advantages are going elsewhere. Why and how?

The strategic concern with the advantages of solutions, is whether to focus exclusively on one particular solution, or one particular type of advantage, or rather to diversify use of solutions or “harvesting of benefits.” IF one solution or type of benefit seems likely to offer extraordinary opportunities, it will be worth exploring how either or both of these could be maximized. On the other hand, if both solutions and their entailed benefits can each only offer modest prospects, then a mix is the more likely way to go.

What has been mentioned previously about some of the examples of benefits, is actually true of all of them, namely that the increase of some types of benefits may be accompanied by the decrease of others. So the idea that all of the benefits might be maximized at once, however attractive, is not correct. When this kind of situation arises, it becomes necessary to look at how much of each potential advantage can be realized before decreases in others kick in. Conceivably, what seems like a smaller advantage might end up actually delivering more benefit because the accompanying decrease in another advantage does not occur until almost all of the initial advantage had been realized. So, the mixing and matching of solutions regarding increasing and decreasing advantages will require careful consideration to determine how and when to engage with different solutions.

Technology Assessment will likely discover or conclude that a number of viable solutions are available, depending on the types, sizes and mixes of advantages that are being sought. These, in turn, will vary depending on whose advantages are being prioritized. The context for these considerations will be what consumers want (or can be persuaded to want), and regulatory regimes regarding performance, safety and security. Under these circumstances, a number of “solution strategies” will likely emerge and be compared. Furthermore, this is only “half the battle,” because each solution may also entail disadvantages. How do deal with them will be considered in the next section.

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DISADVANTAGES

For every advantage that a solution provides, there could very likely be an accompanying disadvantage. Furthermore, the size and/or impact of the disadvantage(s) could be larger or more detrimental than the benefits of the advantage(s). A popular rendition of this insight is that “for every innovation or social change, there are winners and losers.” Even if the advantage(s) represent “win-win” outcomes, the accompanying disadvantages could affect some or all of the recipients, and could range in effect from minor to major.

Anyone who has been in the “innovation game” for a while, will recognize and often anticipate what kinds and amounts of disadvantages are likely to occur – they will have seen it happen before, and can “second-guess” how it could happen again. Depending on the stakes however, they will be more or less likely to acknowledge such prospective disadvantages. Designers and/or producers who anticipate earning a great deal money or market share with the advantages of their technologies, will not be particularly happy with conceding that consumers or users may find the detriments of the disadvantages outweigh the benefits of the advantages.

When this type of situation is looming, designers and producers will often try to “pretend” that the disadvantages are non-existent, or minor, or just “co-incidental.” In these circumstances, the last thing they want is to be subjected to public accountability! If the disadvantages are minor, perhaps they can be classified as simply “inconvenient.” But if there is the prospect that the disadvantages will be major, Technology Assessment is employed precisely to identify this likelihood, AND to recommend action to avert it.

As with advantages, so in the case of disadvantages, the first chore is to spell out what kinds and amounts of disadvantages are looming, what the different detriments will be, and what strategies of avoidance are available. Does a particular disadvantage occur directly as a result of the technology’s functioning, or is it an after-effect? Does it manifest itself immediately when the technology is introduced, or is there a time-lag before its appearance? Does the disadvantage involve individual, social, or environmental impacts, and are methods of alleviation “cheap and easy” or “expensive and difficult?”

Does the presence of a disadvantage interfere with the availability of an advantage, or does it just occur simultaneously? Does the disadvantage occur as a result of the way the consumer uses the technology, or is it inherent in the functioning of the technology? Could the avoidance of the disadvantage be “covered” by proper training or instruction to the user, wherein certain forms of operation would be highlighted as undesirable or dangerous, and warned against? A case in point is the use of cell phones while driving a motor vehicle. Despite many accidents, some drivers still use their cell phone while on the road. Since the “instructions solution” to this disadvantage often does not “work,” the other proposal is to install something that would
disable the operation of cell phones while in motor vehicles. On the basis of performance, this “intervention solution” should replace the “instruction solution” in a good many cases.

Do any of the disadvantages pose a serious or catastrophic prospect of impact? The risk of any such impact is calculated by multiplying the probability of its occurrence by the extent of the foreseeable damage – hence, even very unlikely incidents could still be high-risk if the magnitude of the impact would be very great. Atomic plant melt-downs, hydro dam failures, contaminated water supplies, and malfunctioning sewage water treatment, are all examples of this kind.

An interesting dilemma concerning disadvantages can also occur. What happens when some people (designers, producers, consumers or users) regard something as a disadvantage, but others deem it an advantage? Or visa versa, what happens when what some people regard as an advantage, other declare to be a disadvantage? Both these conflicting perspectives are common rather than rare occurrences. First, who is on the “advantage” side, and who on the “disadvantage” side? Secondly, how do the types and magnitudes of the advantages and disadvantages compare (about equal, or quite lop-sided)? Third, what is the importance of the advantages and disadvantages (trivial, moderate, or momentous)? Depending on the sizes and importance of the advantages and disadvantages, their occurrence can be ignored (because minor), or must be dealt with (because major).

The principle governing disadvantages is well-known – the Precautionary Principle. The more serious the prospect of harm, the more carefully proposals should be evaluated, and the less likely that they will to get approval. Economist Joseph Schumpeter claimed that “creative destruction” was the social price to be paid for economic progress. Like most other economists however, he didn’t have to actually live with the consequences of this creative destruction! Those who do have to endure such creative destruction have every right to ask those who propose it to justify the costs as well as the benefits, and to do so in the light of the values in the communities impacted.

The “economic progress” that economists see usually consists of a few designers, producers and distributors looking to profit through sales – they have not however taken the time and effort to consider the consequences on the disruption they propose. If the profits they gain and the productivity the economy achieves, are both unevenly distributed, then the “progress” may be little more than a euphemism for “the rich are getting richer, and the poor are getting poorer.” Even when new technologies insinuate their way into peoples’ jobs and lifestyles, the disadvantages may outweigh the advantages, and the detriments may outweigh the benefits. The only way to tell, is to assess the technology for the various impacts it produces, and the costs and benefits of doing so. And since we will never see perfection in this world, we will most probably will have to settle for outcomes that are trade-offs between some advantages and some disadvantages, some benefits and some detriments. Let’s see how that will work.
When it comes to “trade-offs,” the best way to begin is to spell out “the bottom line” so that readers do not develop exaggerated expectations. “Trade-offs” is a fancy term for compromises! In the “real world” there are no perfect solutions – some of the “bad” must also be accepted along with some of the “good.” Therefore, what we are seeking when contriving trade-offs is NOT “the best possible solution,” but rather “the least-worst solution.” EVERY attempt to avoid this conclusion will result in wasted time, resources and considerable frustration, that will only be resolved when reality is finally accepted.

What will trade-offs between advantages and disadvantages, benefits and detriments look like? That will depend on the solution that is cobbled together. There will be several of these types of solutions, each of which will prioritize different advantages and benefits, and minimize different disadvantages and detriments. As previously mentioned, the first principle when assembling such a solution, is the Precautionary Principle: do no more harm that is absolutely necessary. Even the best solution ever invented MUST be foregone if it also entails inordinate risk and/or inevitable catastrophic harm. The entire basis of “learning from experience” is that it can enable “survival strategies” — to work however, consequential stupidity (refusal to learn) must be overcome (or isolated and neutralized).

Therefore, the first task is to survey all of the proposed solutions to ascertain the types of advantages and disadvantages they entail, together with the degree of risk or harm those disadvantages may bring. Then a benefit-detriment calculation could be estimated for each of the pairs of advantages and disadvantages. Any indication of toxic effects to the environment or people would have to be either designed out, or the solutions involved would have to be foregone. Such effects as environmental pollution or degradation, or forms of physical, psychological or sociological harm, would all be covered here.

Next the evaluation of trade-offs could look at functionality aspects. What particular forms of functionality does the newer technology prioritize (advantages), and are the accompanying detriments an intrinsic part of that functionality or just coincidental? We could develop a hypothetical scenario for how the design of the mobile phone might have been put through this process. “Increased accessibility” was one of the features initially prioritized and emphasized in advertising. Many advertisements were developed in which individuals were doing tasks away from a “desk phone.” Suddenly they could get an important phone call because they had a mobile phone — the importance and urgency of these situations was “played up” in numerous little vignettes, all with a very clear message (implied or stated): having a mobile phone could save your life, or your job, or your marriage, or your money, etc.

What was the problem with that?!!!! Well, one “disadvantage” that eventually emerged in focus groups was that “24-hour accessibility” might not always be a good thing. Designers, producers,
distributors and service providers all initially resisted this suggestion – they envisioned people willing to talk on their mobile phone at all hours of the day and night. Eventually some of the focus group participants suggested that “you could simply use the off-button when you didn’t want to receive calls” (while sleeping, at movies, or in meetings, etc.). “WHAT OFF-BUTTON?” the designers, producers, distributors and service providers incredulously asked, “THERE IS NO OFF-BUTTON!” [I was part of this process on one occasion, and I can assure you that it did happen!]

Those involved in the mobile phone business were eventually prevailed upon to install an off-button as well as volume-control. The lesson for the rest of us however, is apocryphal: (1) Purveyors of new technologies often cannot see beyond their profit margins; and (2) users should be part of the design process AND the Technology Assessment process. What should also have been anticipated in those early days, was the aforementioned problem of mobile phones being used while people are driving automobiles. A gizmo should have been installed in every automobile that disabled the use of a mobile phone for anyone in the driver’s seat while the vehicle is operating. ALL automobiles should be retro-fitted that way now!

Convenience is a fine thing, but not when it leads to accidents and deaths, nor when it leads to throw-away containers for food and beverage items. A small deposit that is redeemable upon return should apply to ALL such containers, and would go a long way to eliminating throw-aways! It would also provide recyclable materials, and jobs for the personnel needed to organize the collection and sorting.

What kind of trade-offs are generally involved in technology design, deployment and assessment? Designers, if they are given a “free hand,” will produce results that emphasize their capabilities in the features of the product. They could be designing for novelty, or conventionality, or safety, or style, or any number of other considerations – but whatever the “design agenda” is, this could be discerned by the “look and feel” of the product. Many designers have “signature” aspects of their designs that they incorporate into any items they produce.

Producers want lower costs and appealing styles so that sales will be assured and profitable. To achieve this however, they are notorious for skimping on materials and safety/security features. Customers want convenience, low purchase and servicing prices, and often have stylistic preferences that have little to do with functionality and much to do with “impression management” (they want to show off!). But if considerable numbers of consumers and users are involved in design, deployment and assessment, different ones will raise many of the points about safety, security and functionality that do ultimately influence the performance of the technology in question. They don’t have to propose how a disadvantage or detriment will be rectified, just why it should be changed (because it provides inadequate/inappropriate functionality, is not user-friendly enough, lacks certain safety/security features, etc.). If and when consumer want dysfunctional, or unsafe, or too complicated features, these suggestions should be rejected, with reasons given (no bad ideas please!). Acceptable trade-offs will emerge from negotiations between all those participating in the Technology Assessment process.
Negotiating an acceptable solution is still not the end of the decision process. That negotiated solution is an agreement, committed to by the people involved. Implementation still has to be achieved, and there are choices in that process that will determine what actually happens (and doesn’t happen). To a considerable extent, these choices should be tentative rather than “cast in stone.” Producers in particular have cultivated the practice of trying to “freeze” a design/production/deployment solution as quickly as is feasible (for them), and then resisting any suggestions for change from that point forward.

The producer rationale for this is two-fold: (a) the complexities of the design process necessitate that a workable solution be mandated and strictly enforced; and (b) the entire design/production/marketing process is so investment-intensive, that too much money would be “wasted” on anything but minor changes. As previously explained, the first concern results from the design paradigm that is still all too frequently used, i.e., complex, tightly-coupled layout and functioning. The more complex and tightly-coupled a design is, the harder, longer and more expensive it is to change, regardless of the rationale for such changes. Modular design is the alternative design paradigm which CAN accommodate design changes, BECAUSE the layout is not unnecessarily complex, and the modules are each modifiable without requiring extensive or elaborate changes to other modules. However, modular design does require a new mind-set, something that designers and producers who usually pride themselves on their dynamism, are surprisingly reluctant to learn (and you know what “refusal to learn” really is!).

The second consideration is an inevitable result of the first – because existing designs are so intractable, they are over-priced. Once producers have settled on their choice, they mount a “poor little old me” campaign to rationalize why as the “experts” and “entrepreneurs,” they should be given carte blanche to manufacture and market their products – they claim it’s just too expensive to incorporate any changes suggested from the outside, and besides they are the one who “know the market” anyway! What this might look like is a situation where producers have inadvertently “painted themselves into a corner.” If you believe in profound producer stupidity, this explanation might seem credible. More likely however, producers have deliberately put themselves in this position so they can then rationalize their inflexibility whenever it suits them, especially when more time and money are involved.

Albert Einstein observed, the way to change results is to change what you are doing. THIS is a choice that producers definitely have – the old paradigm of complex, tightly-coupled designs, limits flexibility, improvements, and retro-fits needed drastic revision. But it does “excuse” over-controlled, overly-expensive, and under-responsive behaviors towards outsiders. If the only consequences of this were higher prices, producers might (sadly) continue to behave this way. Unfortunately the impacts of technologies are becoming an ever-increasing threat to us all.
FIRST-ORDER EFFECTS

Choices, like ideas, do NOT have any intrinsic value in and of themselves – it depends upon the value they provide to their practitioners. “First-order effects” are immediate (right now) and proximate (close by) results of particular choices. This is a good occasion to refer back to the goals previously prescribed. There are two types of indicators of goal achievement: (i) Lag measures are the ultimate results being sought, but they will only be manifest at the end of the change process; (ii) lead measures are the things that can be influenced immediately, but whose rationale is their sequential contribution to the ultimate results. Lead measures are proximate, but instrumental to the larger goals. Lag measures are distal, but amount to the goals actually being sought.¹

Here we may encounter a difficulty – although lead measures are only temporary objectives from the point of view of the larger goals being sought, the disadvantages or detriments such lead measures produce, may disqualify them from being attempted. For instance, a new production technique (Nanotechnology) will, in the process of being implemented, render all previous production techniques obsolete, thereby destroying millions of jobs, thereby eliminating wages and salaries for millions of workers, thereby reducing the majority of humanity to extreme poverty, while simultaneously making consumer products so easy to produce that there will be gluts of products, etc., etc., etc.

This process will make all previous “social revolutions” look benign by comparison, yet – no proposals have been forthcoming for how to handle any of these transition challenges! Nanotechnology would virtually destroy ALL of the social infrastructure of the entire developed and semi-developed world – only the natives of Borneo, the Upper Amazon, and the Australian outback would be relatively immune from these effects. IFF this process is actually to be implemented, it will require the biggest proposed social re-organization in human history, far greater than either the “agriculture revolution” or the “industrial revolution.” Anybody who does not recognize this requirement must be classified as “profoundly stupid.” [I personally favour the use of Nanotechnology, but ONLY if it is accompanied by the social changes needed to integrate it with all of the other social institutions.]

There are a multitude of possible “first-order effects” that can be produced by, or follow in the wake of technological deployments. And as Joseph Schumpeter proudly proclaimed, most of them will be disruptive to one extent or another. The sociological studies of the first industrial revolution showed that the “absorptive capacity” for change by individuals and groups was quite limited. In other words, the more disruptive social changes are, the more disoriented and depressed most people become. The early stages produce social disengagement, but later stages could result in social breakdown. Be careful what you wish for!

Do people have the right to a particular degree of social stability? Can and should society dictate the acceptable rate of social change? To a considerable extent we already do! Many innovations which promised radical change as a result of their use, were underwhelmed by lack of public interest, and faded into oblivion. When proposed changes are imminent, they rarely face an organized challenge – proponents try to manipulate events so that resistance is overcome. However, on a few occasions when a sizable minority is moved to action, popular demonstrations have actually reversed the course of events. If a big enough turnout persists for long enough, governments will actually facilitate the change summarily, or be faced with the prospect of a general strike. Radical technological change will eventually become one of those “make or break” issues.

If decision-makers were “smart enough” to avoid the pace or extent of change beyond the “absorptive capacity threshold,” there would be no need or occasion for such a backlash, but most modern decision-makers do not seem to learn very much from their experience. The single most important piece of wisdom (life-lesson) from professional experience is knowing what you should NOT do! Most decision-makers develop and implement policies whose lived consequences do not actually apply to themselves. And since they do not “suffer the consequences,” they do not experience the existential deprivations and regrets that policy recipients do. [They don’t give a shit, and why would they?]

Here is an interesting social metric, and a proposal based upon it. The extent of social disruption from social change is directly proportional to the depth, breadth and rate of that change. Furthermore, there is no evidence that “change for the sake of change” is a desirable policy. Certainly, proponents of change are eager to list the advantages and benefits contingent on such change, while ignoring or denying any drawbacks. By their own behavior, technology proponents demonstrate that social approval is the basis for acceptance of new technology! Therefore, all proposals for social change should get the approval of those affected BEFORE those changes are authorized to be implemented. What this proposal suggests is that proposals for social change are not automatically acceptable, but need the mandate of those affected.

We generally “lionize” proposals for “progressive social change.” But we do so in a generally naive way. We don’t know “what we’re getting into” nor what the consequences will be. But everyone (with very few exceptions), agrees on the merits of “choice,” we can and should choose what kind, rate and extent of social change we will accept. This is an admittedly radical view of choice, but so was democracy in its early days (the idea that we could choose the government we got, was a profound historical departure from past experience). We can now go beyond the myth of inevitable progress and choose our own version of progress.

We have many more choices than most of us realize. If we do not actively exercise those choices, we have no one but ourselves for the way the future turns out!
SECOND-ORDER EFFECTS

What about the “long-term effects” of our choices? To adapt a maxim, if we don’t control our own future, someone else will control it for us. All of the other creatures in evolution don’t have the brains to control their destinies – we do, but do we have the “smarts” to make the correct choices? That remains to be seen!

Certain biotechnologists are proposing (and planning) for humanity to be replaced by more advanced “trans-humans.” By labelling the process with euphemisms, they are trying to make the process of genocide palatable. This proposal is so ludicrous that it should be confined only to bad science fiction, but alas it is not. Some want to begin by uploading human consciousness to a computer network. But human thought depends on sensory inputs from the entire biological body – it’s not just “data points” on a network or in a repository. Without the range of sensory inputs, you don’t have human thought. This proposal is a wonderfully stupid one, from those who have lost (or never found) the grounding of human existence. How would this transition take place? NO SUGGESTIONS, just the claim that it is the wave of the future.

I would not be surprised if a new movement of social radicals begins to form to stop the imposition of such changes before there has been the opportunity to discuss these options openly, and develop a consensus around them. Their mantra would be something to this effect: NO CONCRETE ACTION ON THESE PROPOSALS UNTIL AN OVERWHELMING CONSENSUS FORMS AROUND WHAT POICIES TO ADOPT REGARDING THEM. Any pre-emptive moves by trans-humanists over-enthusiasts would encounter the displeasure and discipline of this HUMANIST MOVEMENT.

The foregoing case is but an extreme example of “second-order effects” and how they are dealt with by both producers and consumers – they are usually ignored, belittled or denied. These three responses all fall under the practice that economists can “discounting the future.” This is the contention that “the further into the future an event or experience is likely to occur, the less influence it has on immediate concerns.” In other words, according to this contention, most people don’t think very far ahead. To the extent that this is correct, it is NOT the result of “human nature,” but rather of “consumer culture!” A large proportion of advertising and marketing is dedicated to instilling in consumers this particular habit of thought. However, there are mortgages and lay-away plans, so even advertising and marketing are not entirely devoted to encouraging “immediacy.”

With regard to producers, their dedication to either proximate or distal goals is largely strategic. They will jump at an immediate opportunity, if they believe it serves their purposes, or forego such an opportunity if they believe it will not serve their purposes. Just as readily however, they will invest substantial resources in long-term opportunities, if they believe it serves their purposes, or forego such investments if they believe it will not serve their purposes. Their penchant to “ignore, belittle or deny” the prospect of second-order effects of technologies, is based on their preference to “get their own
way” and their excuse that “it will cost too much money” and “take too much time” to assess technologies thoroughly. In other words, they are far more interested in recovering their investments AND making as much additional profit as possible, rather than acknowledging that their technologies may eventually produce as many, or more detriments than benefits. Is this the kind of outlook we want impacting our future to an increasing extent?!

A pervasive example bears repeating: the automobile produced paved roads and highways, suburbia, shopping malls, massive release of green-house gases, traffic accidents and deaths, leaded gasoline, road-racing and road-rage, traffic jams, etc., etc., etc. Some will argue that the early automobile inventors did not have the wherewithal to forecast or assess such impacts. Perhaps so, but our subsequent experience does now give us this wherewithal to forecast and assess such impacts! Technological change is not “inevitable” or somehow “natural.” Most innovations FAIL to succeed and produce substantial change.¹ The small percent that do succeed could have been designed differently – in fact, they often go through successive versions in which any number of features could added, subtracted, or significantly modified.

All of the above leads to a general “rule of thumb” for ALL impacts produced by technologies. The more successful an innovation becomes (for whatever reasons), the more impacts it will produce, both trivial and important, both proximate and distal, both superficial and deep, both easy to rectify and difficult to rectify! ANYONE who denies this outcome, is either a fool or a liar, and in neither case are they to be trusted regarding this issue (I suspect this denial is simply an attempt to try shirk any responsibility for dealing with the impending impacts).

Not all second-order effects are detrimental (nor are all first-order effects). Benefits quite often emerge unexpectedly, and these are to be welcomed. BUT the notion that “the benefits are the main thing” and that “therefore the detriments can be ignored or minimized,” is nothing more than an attitude of negligence regarding both society and the environment. [Yes, but you have already said that! True! But it bears repeating again, and again, and again, etc.] A person who accidently steps out in front of speeding automobile traffic may be careless, or accident-prone, or just unlucky. But a argument applies by analogy to the whole of society when it comes to cavalierly adopting new technologies. Modern societies “developed” the institution of elected government when both royal and aristocratic prerogatives were no longer tolerated. How much risk will new technologies have to pose to human survival before we will say “enough is enough” and institutionalize a method to assess and manage such risks? As the title of a book on this topic implies, when we ignore these concerns, they come back to bite us (in the ass)!

COMPARISONS

After listing the advantages and disadvantages of alternate solutions, and exploring the first-order and second-order effects each entails, choice will come down to comparing to see in which one(s) the benefits exceed the detriments. Once these comparisons have been made, the choice will favour either more benefits than detriments, or sufficient amount of a crucial kind of benefit that the decision premise is prioritizing.

Then presence of a particular type or amount of a specific disadvantage in one or a number of solutions could disqualify them immediately from consideration. If the new technology was a drug, and there was evidence of a lethal level of toxicity in certain of the possible formulae, those lethal alternatives should be rejected (and be removed from any further consideration). If on the other hand, a particular level of an advantage was required, those alternatives that did not provide that amount of the desired advantage should also be taken off the eligibility list. If a new piece of equipment requires a user-friendly operator interface to enable proper control, and tests show that one or more of the alternatives being considered is not user-friendly enough, those candidate solutions should also be removed from consideration.

Conversely, solutions with a high proportion of a desired advantage might be tolerable even with some accompanying disadvantage, provide the level of advantage was high enough and the level of disadvantage was low enough. A new, cheap ball-point that was developed to provide a clean flow of ink, would likely be acceptable despite the disadvantage of an occasional leak, provided it could be manufactured and sold at a competitive low price, and the leaks were small and few. When there is an abundance of a desired advantage, but too much of an accompanying disadvantage, the disadvantage must be eliminated or the solution foregone. If a newly engineered racing car accelerates very quickly (a big advantage), but the braking system is slow to respond (a big disadvantage), the braking system must be improved to the same standards as the accelerating system, or that particular design fails the safety test and should be discontinued.

At what point should advantages be prioritized or disadvantages rejected? That very much depends on the technology in question, and the nature of the advantages or disadvantages. Part of the challenge here is that different people make conflicting ratings for both the size of the advantages or disadvantages, and the actual classification of a feature as an advantage or disadvantage. People who discard empty beverage containers in any and every convenient spot, do not see “public clutter” as a major disadvantage. Many environmentalists however would just as soon ban disposable beverage containers entirely, as have them randomly discarded. Should a newly developed beverage be sold in disposable containers?

What about the situation where a publicly perceived advantage is “officially” designated as a disadvantage? There have been some plans and some attempts to develop a low-cost automobile to appeal to poorer consumers. In some cases however, the safety features of such automobiles are minimal or entirely lacking. Rigidity to protect passengers in the case of impact, is a case in point – some of these “new cars” are alleged to provide insufficient padding, or lack structural integrity – but
surveys indicate that “the poor” would still rather have them at a lower price than not. Should these automobiles be authorized for manufacture and sale?

The inverse of the above situation can also occur – what happens when a new technology is officially approved and recommended, but most the public is not interested? Many new “healthy foods” are developed quite regularly, and given approval after testing for nutrition and quality. But “healthful snacks” are not usually best-sellers, and many producers of them eventually take them off the market for lack of sales. Instead, potato chips, chocolate bars, popcorn and other “junk food” are greatly preferred by consumers. Is it worthwhile to try and develop yet another “healthy treat” that could very well experience consumer rejection?

By the same token, official disapproval of certain products has not prevented their continued sales. Cigarettes are a good example – smoking causes multiple health problems, particularly as people age. The government in certain jurisdictions actually requires the printing of health warnings on cigarette packages, but many people still smoke. In this on-going battle, smoking is now banned from many indoor public venues, but many people still smoke. Should more onerous restrictions be placed on smoking (regulatory techniques are a form of technology), or should smokers be given freedom of choice?

The bottom line regarding advantages and disadvantages, or benefits and detriments, is that their classification and rating is “in the eye of the beholder.” There are a lot of exaggerated, unrealistic expectations about how much public behavior can be influenced by either authoritative pronouncements or rational arguments. The philosopher Plato, the ultimate rationalist, set the pattern for such delusional thinking by supposing that by “talking up” the idea of an elitist meritocracy, the citizenry of ancient Athens could be persuaded to adopt his plan for a Republic. Every subsequent attempt based on that same premise has encountered equally dismal results.

Practitioners of marketing have learned to rely on the only technique of persuasion that consistently works – this is the WIITFM strategy: What’s In It For Me? (or, in the case of a group, WIIFU: What’s In It For Us?) Successful implementation works in the following way: Promoters of any product, survey and interview their prospective customers sufficiently well enough to learn their values, aspirations and goals (guessing does NOT work!). They then find (or contrive) an overlap between “what the customers want” and “what we have to offer.” In other words, it is one version or another of “your (customer) interests coincide with our (producer) interests, and this product was designed to help fulfill those interests.” The entire commercial civilization is testament to the fact that the technique actually works! Will advocates and promoters of Technology Assessment be wise enough to make the “smart choice” and use the one persuasion technique that has proven its efficacy? The stakes have never been higher (human survival), but even in these circumstances, self-righteous pontificating will not achieve the goal of assuring human wellbeing. Here is the tag line: **We all have an interest in surviving, but that won’t occur unless we replace exploitative economic activity and uncooperative social organization with reciprocal social relations and sustainable economic activity. Technology Assessment is part of that reciprocity and sustainability.** We should get started immediately!
Conclusion
A SUMMARY OF TECHNOLOGY ASSESSMENT

Premise

A policy of promoting innovation ought to be geared to the capacity of our society to absorb change in an equitable and broadly enriching way. The more complex emerging innovation become, the more chance there is for deliberate or accidental misinformation, confusion and obfuscation. Whenever there are reasonable means to guess at damages in advance, prospective regulation makes sense, and may be much more equitable for all concerned than after-the-fact procedures.¹

What matters most is whether we are contributing to a system that will be good for us all in the long term.² The Moral Hazard is the temptation to risk social wellbeing for personal gain.

Preface

Concern is often expressed that assessment of technologies prior to deployment, would be too cumbersome and not acceptable to those marketing such products. However, in the case of new drugs, pesticides, and food additives, this kind of assessment is already in place – the results from Thalidomide, DDT, and food poisoning overcame resistance to such regulation. What is proposed is that many of the new technologies now in development (Genetic Engineering, Big Data, Applied Neuroscience, and Nanotechnology) will have even greater impacts than anything since the invention of agriculture and writing.

Procedures

No idea or proposal has the right to be accepted or respected in the same manner as do individuals – every innovation needs to be challenged as to impact and accepted, modified, or rejected on its merits. This is the purpose of Technology Assessment.

Technology Assessment will receive the most widespread support if it is open to all sectors of society. Participation can be voluntary, but in every case should include experts, innovators, business people, policy-makers, and the general public. Both the OECD and the European Union have developed Technology Assessment methods quite extensively; all that is required is the political will to apply such methods whenever appropriate.