Socio-Technical-Natural Systems Thinking (STN)
Technological Dreams, Sociological Repairs, Natural Cleanup?

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Abstract

The focus of the paper is 19th Century industrialization. The research emphasis in this area was long with improving productivity via implementing new technology. Russell Ackoff, through his development of Operations Research, brought some changes to this emphasis. His work criticized the overriding importance of the technological imperative in production during and after WWII. Simultaneously, another researcher, Eric Trist of the Tavistock Institute, worked to elevate the humanistic aspect of industrial operations. The social and psychological dimensions became his variables for improvement. Ackoff and Trist later came to be developers of Systems Thinking. They initiated a new program in social systems sciences at the University of Pennsylvania in 1975.

The point of departure for this paper is the work of Trist. For him, it was important to place the technological in a sociological context. The Ackoff's work in Operations Research (OR) was important to also including context in the science of OR, but with his departure from OR in 1967 he emphasized the shortcomings of OR in avoiding the systemic.

For this paper, note is taken of research for adding the digital technology expansion to the socio-technical agenda. Beginning in the late 1970s, with Cal Pava a student of Eric Trist, this work was known as "socio-tech in the digital coal mine." Other researchers have continued to pursue the digital theme in socio-technical research. The point herein is that this may soon be overshadowed by threats to then from the larger context of the industrial – the natural environment. There are long-standing problems in this domain that are becoming more noticed. They relate to effects of industrial production and product use in the natural context. Can the socio-tech model soften the effects and consequences of industrialization on planet earth as currently called climate change?

Keywords

Socio-tech, systems thinking, Tavistock, Trist, Ackoff, Vickers, Pava, computer-technology, natural systems, industrial, artificial constructs, negotiated order versus legal order, Social Systems Sciences Education, climate change.

1. Introduction to The Problem

In 1687, via promises of beauty in rationality, Sir Isaac Newton offered a quantitative passage to improving the conditions of human life. This would come to supplement and then to replace the history of hope from belief in religious promises, ones that Newton also believed in. Newton's work was to outline a non-religious, more rational, mathematical route to humans attaining self-determination in meeting human needs. His work came to be fundamental to the making of machines, and giving a form to

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industrialization. Industrialization became important to meeting human needs. It was later extended to attempts at providing for human wants, no matter their degree of superficiality.

Newton proposed strict rationality to create improved conditions for human life on Earth. This was to counteract shortcomings he had observed in questionable nature and human behavior, in some aspects of which he too was guilty [1]. Newton thus authored a method to mechanize progress, which continues to this day. Mechanization even expanded into modern warfare. Newton worked hard to avoid the appearance of the non-rational [2].

Mechanization became Industrialization. It became the essence of human hope for progress to raise humans above nature's limitations. Newton's ideas thus spread rapidly. His understanding of structure and force was used to collect raw materials from nature, then organized them rationally to build production processes to then produce goods. The industrial process was the rational organization of machines to rationally produce rationally designed products alongside not-so-rational humans. Humans were to act ever more rationally to work alongside machines. Gregory Bateson remarked on the human dilemma: "Humans will need to become more predictable, or the machines will become angry and kill them." Humans attempted to leave their non-rational nature behind while at work.

Thus, the industrial became a growing problem for the natural context. This was seen in human efforts to expand the industrial from the early 19th Century. At the end of WWII, the problems in this were becoming more apparent. It was then seriously questioned by Systems Science theorists. They pointed to the central measure of industrial success – productivity. They showed how an emphasis on improving productivity led to continuous growth in what was coming to be the wrong things. These theorists brought redesign to the situation in what they called the socio-tech system-thinking model. Their early questions and work set a basis for considerable improvement to several industries. Putting the social back in control of the mechanical led to improved production process design and management. Optimism in improving the process of meeting human needs and wants was emerging and expanding.

Unfortunately, a larger problem for industrialization, one that had been lying in wait for decades, surfaced in the 1970s. It dealt with long-term expansion of industrial consumption of materials and energy as needed for production and use of products. The problem was that those long involved in managing the process had ignored longer-term costs in what they were doing. They had of course seen limits to the industrial process but those were in production, not in unwanted pollution side-effects from mining and refining materials and energy needed for production and its products. The natural context that had provided the inputs was expected to absorb such unwanted outputs. Somehow, humans had learned to ignore such. Newtonian-inspired humans forgot they were part of nature where their life depended on the well-being of the natural context. The outputs of industrial production were finally being seen to deteriorate the natural environment in an irreversible manner.

Nature, the context of human existence, had long been disregarded by most humans. Newton seemed proud of proposing that nature was subordinate to human reason. He noted: "The latest authors, like the most ancient, strove to subordinate the phenomena of nature to the laws of mathematics."[1]

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(*Principia Mathematica, Book 1*, 1687, from Newton's preface.) [Ibid. reference 1] Later, via Newtonian organization, industrialization seemed to represent a force more powerful than the nature surrounding it. Humans, as part of nature, came to see themselves as subordinate to the rationality of the machine. Now, via the selling of AI, we see this logic expanding. Humans have come to accept dependence on machines for food, shelter, and satisfying their wants.

Larger systems of order and life are clearly beyond Newton and the artificial, yet humans continue to see machines as critical to life as they know it. Thus, machines have expanded from providing for needs to responding to human wants and desires. They were even made available to fight in God's war with nature, as prescribed in Biblical teachings, and then adapted to the long-standing wars of humans with each other and even themselves. The problems with the human project were not getting better, only more clearly harsh.

Processes and products of industrialization thus became ideological tools in a war against nature's variances and uncertainties, and even wickedness. The making and using of technology in production, and products coming from it, became a new spiritual, not an opposition to the spiritual. Humans loved it. Machines and design of the artificial came to be the essence of the human project. Machines were tools for what humans could, would, and should do. Much of this ideology remains in the teachings of public schools. This logic has been expensive to life.

Newtonian dreams of reason came to underlie the ever-expanding human idea of progress via a partnership with the ideas and the manifestations of technology. Technology replaced religious aspirations before becoming a replacement religion. The industrial ideology continues through the post-industrial aspirations of Artificial Intelligence. Dreams of advanced technology appear as the warriors against an entropic death. This has replaced the tradition of religious promises of life reappearing after entropic death in a non-entropic setting. Providing extensive immortality projects, the technological imperative seemed secure once again.

2. 1950: Socio-Technical-Systems Thinking as a Response

We humans occupy a context that has come to include the importance of the social along with Newton's technological. Changes in the socio-technical context redefines the meaning of being human. Such change was significant at the close of WWII. The technology of war and the factories that served it had changed a great deal during the war. It seemed to have outclassed the importance of the social. The industrial was thought to serve the social, but the significant changes in the technological were presumed to service the industrial, not the social or the human. During the war, the technological was greatly advanced in the name of winning the war. Its development had become the imperative. The social was presumed to be secondary to progress and would be adaptable to technological requirements.

This idea changed with the ending of war. It came to be noted that the technical was becoming a danger to the psychological. Thus, the technological needed to be reconsidered then designed to support the psychological and serve the social. First efforts were undertaken to make this change in 1950 via work carried by the Tavistock Institute of London. Eric Trist of the Tavistock Institute led innovative research into relations between the sociological and the technological. He found a significant and expanding

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technological imperative from the "tech" of WWII. By adopting a systems-thinking attitude he helped improve the perception and management of relations between the two. This work came to be called socio-technical systems. Many industrial settings were seen to operate via a technological imperative. This needed to be changed.

In the 1950s this change was crucial, but only in isolated locations. Even into the 1970s and 1980s it was not widely accepted. It was mostly a tangent to what mattered more - socio-technical was an obstruction to the Social Darwinism clarity of Milton Friedman economic brutalism.

> "In Britain, also early in the postwar period, a new direction of development toward the new collaborative model began through the discovery of the autonomous workgroup. This phenomenon gave rise to a new concept, the 'sociotechnical system' (Trist and Bamforth, 1951), which represented a basic critique of scientific management in the technocratic bureaucracy." [4]

Eventually, some scientists and mathematicians began to question Newton's strict reasoning and homage to a closed logic. One of the most skeptical, and most humorous, was the Ambrose Bierce in 1889. He came to be referenced by early systems scientists of the 1960s. Russell Ackoff, a systems scientist of the 1970s, often referenced Ambrose Bierce's definitions. The Bierce's definition of logic appeared in Ackoff's writings, and in lectures to companies facing production problems. As the founder of Operations Research, Ackoff used the definition to illustrate OR's future being in the past, and they had missed it.

> "Logic: *n*. The art of thinking and reasoning in strict accordance with the limitations and incapacities of the human misunderstanding. The basic of logic is the syllogism, consisting of a major and a minor premise and a conclusion – thus:
> *Major Premise*: Sixty men can do a piece of work sixty times as quickly as one man.
> *Minor Premise*: One man can dig a post hole in sixty seconds; therefore –
> *Conclusion*: Sixty men can dig a posthole in one second.
> This may be called the syllogism arithmetical, in which, combining logic and mathematics, we obtain a double certainty and are twice blessed." [5]

Social scientists from WWII would sometimes reference the definition in shortcomings of industrial processes that forgot humans in a need to improve machine productivity. The value and welfare of humans had been dropped in an urgent need to improve productivity in meeting war needs. The technological imperative was not questioned until escalating human costs in the system became noticed. Once productivity also declined it became even easier to make changes to the system.

3. 1960: Going Deeper and Wider: Rethinking the Industrial Imperative

A lead in noticing the problem of production came from scientists involved in WWII. The leaders were based at the Tavistock Institute in London. They believed that major improvements were essential and could be made. They called for a revaluation of the logic that had lowered the value of humans in production since 1850, and especially during WWII production. They argued for rethinking, seeing production as a system, and experimenting with a social imperative. They argued how we should think of

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the socio-technical as a system, and have the socio lead the system, reversing the tradition of the technical.

They arrived at this hypothesis through seeing how production was becoming increasingly sophisticated and had properties of a system, rather than a collection of machines lined up turning out parts. After initial experimentation, they went further and began to believe that leadership by the social was not simply better in industrialization but had become essential to its management and continued improvement. This became a call for thinking of *socio-technical systems as processes*.

The industrial process, and management of its social and technical aspects, was thus reconceptualized as a system. The system was explicitly to benefit the social, not the technical. It was posited that the industrial was to serve human needs and wants and must thus be managed via a human imperative. Based on its considerable early successes, this logic spread to most industries.

During the 1970s, the socio-tech's model of success encountered questions about the price of, and limits to, that success. This arose in the 1975-77 work of international business researchers who came to be skeptical of the 1850 industrial process and its consequences for systems of life. Industrial inputs, outputs and outcomes raised previously unasked research questions. This began with concerns about environmental pollution and environmental protection.

The research soon moved to questions about the assumption that social regulation could take care of the externalities of industrialization of processes and products. The industrial model resulted in good and bad, where both could be regulated. Different approaches from different nations were studied. It was soon found that the good from industrialization needed to be much better, and that the bad might well be too bad to regulate. Shocking long-term consequences were identified from the research, e.g., climate change. Short-term gains were even seen to be a problem, in that the public lost concern for the initial signs of deterioration of their environment. It has become much like a Faustian Tragedy.

Those involved in this research were well-schooled in socio-technical studies. Their thinking was that Trist's work, which had moved production management from a technological imperative to a social imperative, was only a first step. It could not begin to address the fearful consequences of continued business as usual, even with a social imperative. It seemed that moving to a natural imperative was necessary, and more research was needed.

Concern was with the harmful consequences from environmental desecration, values intrinsic to Newtonian industrialization, and then in the design of products produced. The social should continue as an imperative in socio-tech management, but the total system needed to embrace a larger system that would include natural resources and systems of living order. Evidence from a 1977 report to OECD, pointed to ways in which human actions were changing the conditions of life on the Earth. Key in this change were industrial production processes and human uses of the final products. There was a call for a natural imperative to manage the three-part socio-technical-natural system that was to meet human needs. The social had shown much progress in redesigning management of the technical since 1950. Could the natural follow a similar path?

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In the following section the most extreme example of a socio-technical systems project was studied so it could be expanded to other sites. Due to the exposure of its very radical results it was closed, and its management were fired for not understanding the importance of management in the industrial. The example had been set up using the Eric Trist model of socio-tech. The research for it was carried out using the Trist idea of Action Research.

4. 1974: An Extreme Socio-Tech Project: Scott Paper, Dover Delaware

Two PhD students working for Professor Eric Trist, David Hawk and Bill Henderson did this work for Scott Paper Company. Their objective in doing it was to become noticed by BusinessWeek for working at the edge of business innovation. Scott Paper had a new paper plant to build and had asked Eric Trist to advise on how it could be innovative. Headquarters soon forgot about this venture, since they had 33 other paper plants to manage. Eric Trist thus worked with the plant manager to do something "noteworthy" for the human future, as he always tried to do. As research and teaching assistants to Eric Trist he asked Bill and David to do an evaluation and to look at what was accomplished in the socio-tech domain at the Dover, Delaware plant.

The essential research question was how much of the gains generated by the 1950s model of the socio-technical in English coal mines had been achieved in this new Scott Paper plant? The project began in 1975 and it took six months to conclude in a report on the plant status.

The two researchers spent many days at the plant, interviewing about the 150 employees and one manager, while also coming to understand the technical processes. Production technology had never been used before in the industry. It had been designed to reduce greatly the environmental pollution effects from its operations. The products were paper towels designed for cleaning and reuse. Many problems emerged in the technology including numerous fires and breakdowns. The products needed to be continually tested due to production issues.

The social aspect had been designed in accordance with the Trist advice on setting up an ideal socio-technical system. Professor Trist had worked with the gentleman who was to be the plant manager in the new plant in Dover, Delaware. The manager had come to know a great deal about the potentials in a socio-technical systems approach to plant set up and management. He organized the social aspect around the idea of the five-person autonomous work group. Each group was self-managed. As with the coal mine groups, one member would be in charge of an operation, its leader; another two would be doing the manual work, where needed; and a fourth would be responsible for seeing accidents, running tests and improving safety. The fifth member could stay home when not essential to the day's work. Even with many technological breakdowns, the productivity of the plant was 30% better than other plants, or than had been anticipated. It was perceived as the best in the industry.

Things were going so well at the plant that the plant manager decided to avoid seeming to hang around to watch the successes, so he moved to his home and rehired himself as part-time, with part-time pay. The workers greatly appreciated the meaning behind this move for continuance of their self-leadership. Their productivity further improved. Workers then made proposals to headquarters about redesign of the production technology, much of which was carried out by third parties. Throughout the

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plant there was evidence of a competence hierarchy having replaced the usual managerial hierarchy. This was written up in the final report with examples. However, it should have been left out of the report to the Board.

The Board of Directors of Scott Paper was the client to the research. They had asked for information of spectacular successes in their new plant in Dover. Their plan was to provide this information to BusinessWeek to capture the attention of the paper industry. A previous news article on innovation in a General Foods plant was what they wanted to also be recognized for. The two researchers and Eric Trist thus made a presentation to the Board on innovations in the Dover plant.

Halfway through our presentation the CEO called for a halt. The corporate lawyer had drafted a document we needed to sign before we could continue. It was that we would keep the information about the plant confidential and never write a public report or science article from it. We signed this document, then completed our presentation. The CEO of Scott ended up firing the plant manager, then brought a union into the plant to help formalize work processes. Changes recommended by workers were frozen. Later, the same Board fired the CEO and began a search for a replacement. Eventually Al Dunlap became their dream CEO. He was the darling of Wall Street. He promised to double productivity in any company that allowed him to be their leader. Eventually he was hired by Scott Paper's Board to be their CEO.

CEO Dunlap doubled plant productivity within six months. He fired about half the workers. He got rid of Customer Service, then Research and Development, and then fired many plant workers. Two years later, when complaints emerged about the quality of the company, he arranged to sell it to a competitor. During this process CEO Dunlap came to be titled "Texas Chainsaw Al Dunlap." He was then clearly the darling of Wall Street. Then he took over the leadership of a company where he stayed a bit longer. He took that company into bankruptcy and was fired by its Board.

5. 1983: A Need for Socio-Tech Systems to Include Information Systems

Eighty years later, some researchers that also worked with Eric Trist became interested in the relevance of socio-tech-systems ideas in the IT operations of firms. It seemed to them that IT was becoming a new version of the pre-1950s version of the technological imperative in management. Their question was: Could socio-tech be used to help those attempting to manage the unfolding of Information Technology as applied to continuing needs of traditional industrialization? The 1950s Trist era of socio-technical systems came from an urgent need to reform an industry essential to other industries in post WWII England – coal production. Coal was then the major source of energy where energy was essential to reconstruction. The Trist cases improved productivity about 30%, which was remarkable. What was learned from these cases came to be expanded into many other industries for the next fifty years.

Some researchers noted growing similarities between Information Technology of the 1980s and the coal mining technology of the late 1940s. As such many looked to socio-tech thinking for help. The work of Cal Pava in 1983, one of Eric Trist's students, is often used as a foundation for this domain. It, and Eric Trist's thoughts on it are briefly outlined here. Pava had become concerned that the technological imperative had taken over the office, via a greatly-expanding use of Information Technology. He found similarities to what Trist had found in the coal mines thirty years previously.

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Pava's friend, Bill Gates, provided Pava with clear examples of how things were going wrong. The results of these studies came to be significant to the next stage of socio-tech development.

What was learned and applied via the Eric Trist "socio-technical" conception for managing relations between the social, e.g., workplace, and the technological, e.g., machines at work, is important here. The context for these relations is an industrial-based society, where technology is increasingly applied to meet human needs (food, shelter, safety, etc.) as well as to satisfy the ambiguity of human wants (ownership of things, control over life, respect from others, happiness, etc). Current development of the socio-technical world is through ideas on how best to relate social systems to technological systems, where the technology is primarily digital in its design, production, and operation. This is different from the coal mining context that stimulated the Trist work at Tavistock. Taking note of this, some from the digital world renamed the context as "Digital Coal Mines."

The widely accepted dominance of the technical over the social was acceptable until the work of the Tavistock researchers at the end of WWII. They reminded society of the importance of the social over the technological. But now, seventy years later, it seems the technological is gaining predominance once more. Here we go again, moving away from the social while pandering to the technical. It is time to bring the Trist sense of inquiry into the IT world of management.

Within the precepts of industrialization, and its capital costs, we often shift business emphasis towards how best to soften the importance of the social, considering the needs of the industrial. This is clearly demonstrated in what we call the Al Dunlap approach to productivity. From designing more flexible machines for men to use, we have moved to designing humans to be more flexible in their requirements. This is in line with the Babbage logic. From Aristotle to Leibnizian calculus the pathway for programming the artificial has become clear. Warren McCulloch and Walter Pitts illustrated this in the basis of Information Technology management, as outlined in "A Logical Calculus of the Ideas Immanent in Nervous Activity." (Bulletin of Mathematical Biophysics 5, 1943, 115-133). Thus, we are at the interface of the social and the technical where both have come to be defined by the logic of the technical, especially that from Aristotle.

The emphasis here is with our reliance on a perspective of Information Technology that is decoupled from the social context which it attempts to manage. My fear is that we are again using the thinking that preceded the 1950 development of the socio-technical systems perspective. We seem more than willingly to apply the rules of the technological to the sociological in business. Just now we might look deeper into what was carried out in the 1950s to redress a world gone wrong.

The current Socio-Technical perspective seems opposite to the thinking of the founders of "socio-tech." They appreciated, in the Sir Geoffrey Vickers sense, how the technological was assuming dominance in the operations of the social. Clearly, the technical needs to find reduced dominance in management thinking, in that the social could be better managed to achieve human ends of systems of life.

Bill Gates and Calvin Pava met early in their careers. Pava was a graduate of Wharton, and then a professor at Harvard. Gates was a student at Harvard. They became instant friends, as both came to see

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a need for innovation outside of Harvard business-as-usual ideas. They spent much time in Northern California vineyards and wine bars discussing the future of Information Technology relative to IT providers and users. Some of this found its way into a 1983 book by Pava [6]. Calvin Pava's mentor at Wharton, Eric Trist, was to write the forward, but Cal was in such a hurry that the book got written and Trist's forward had to become an afterword.

Trist went deeply into socio-technical systems and Information Technology. Once more, he feared the technical would diminish the social. It would create an economy with extreme income gaps, and reduced humanity, as in the coal mines. The following is part of his commentary on socio-tech and its meaning for Information Technology.

> "This is a far cry from the prevailing perspective, which concentrates attention so steadfastly on the technological aspect that what-so-ever the equipment makers propose is solemnly installed with the eager support of data processing and internal "systems" staffs. Absent is any informed scrutiny of organizational and social aspects, with untoward consequences: the creation at the lower levels of large numbers of poorly designed jobs which lower performance and increase alienation; failure to appreciate the subtle yet profound changes required in managerial and professional roles; the export on to the labor market of those made redundant without serious thought to their retraining or future place in society." [6]

Pava posed an integrated approach in the field of socio-technical systems redesign to include an increase in non-linear enterprises relative to knowledge work. This helped practitioners move away from an old paradigm of linear transformation processes in factories and offices. Pava's concern was with the centrality of deliberation as the place where work was done. The concern here goes beyond this. From the Pava evolution, we move beyond the digitalized dreams for the human project and call for inclusion of a third element to our equation – the natural context.

Some will quickly see why the addition of nature adds a context for its natural improvement. The 1950s socio-technical, with the 1980s Information Systems inclusions, will be helpful, but insufficient. The terminology at this point is open. The challenge is to arrive at a fluid systemic model of the social, the technological and the natural. Their relations at this point are not clearly known, yet are known to be changing. The paradox in adding the IT to the socio-tech is just now significant, even without the natural. This paradox, relative to humans being human, is brilliantly outlined in a John Brunner book: "Shockwave Rider." From 1975, it came to be the hacker-bible for concern with the predictable human uses of Information Technology [7].

6. The Forgotten 1979: Can There be a Natural in Socio-Tech Systems

Nature has mostly been a backdrop, to be ignored as raw materials are found and forthcoming. From secure industrial resource input, humans concentrate on the technical, the social and their interrelations to better serve individuals. Shortcomings with a technological imperative managing the social in coal mines led to important changes. This knowledge spread to auto factories and other aspects of industry. Just now the entire industrial paradigm faces a problem. Just as humans came to see they were rightfully in charge of the technical, the natural is reminding humans that they come from nature

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and along with the technical they rely on the natural for inputs. The seventy-year history of socio-tech can be a viable guide to finding effective responses to changing the role of the natural within the industrial. These changes may become incredibly significant.

The concern here is that another variable must be introduced into the system, that of the natural. We have long known that nature has provided the context for all things human, as well as providing the resources for the industrial, but nature has been left in the background of the search for progress in meeting human needs and wants. The natural environment has long been the dumping ground for the unwanted parts of the industrial - the trash and waste - through disposal and/or release into the air and water. These were simply assumed as costs of fulfilling human needs and wants. Recently this domain is seen as the depository of costs of social and technical activities.

Can the industrial be reconsidered, as it was in 1950, to respond to an enlarged value system? Perhaps not. We do not yet understand nature. The level of change may be beyond human capability. The following offers a brief outline of the challenges facing humans due to their two-hundred-year-old choices for industrialization. We begin to see why it must be radically changed. We do not yet know what this change means. We may need to abandon industrialization. The youth of today are not impressed with our version of industrialization. Perhaps the remarkable 1950 socio-tech repair of industrialization by Eric Trist, et al can be taken to include the natural. We do not know. We do know we need to find a way to move from desecration of nature to appreciating its fundamental importance in larger systems.

40 years ago, there was a call to expand the socio-tech of 30 years previous. The expansion was to include nature within the socio-tech model. Some research came from this, which became a call to develop "business-as-unusual," well beyond the entrepreneurial. This was to systemically repair industrialization via different models of production, consumption, and product design. The call was soon ignored. Little change resulted to industrialization. Part of the call for change resulted from research into the consequences of climate change. These consequences were thought likely to damage life on the planet if change did not take place in the ways in which humans met their needs and wants. How do we expand the success of the socio-technical by adding the natural? This is the question here.

In the mid-1970s, another advisee of Trist, David Hawk, traveled a different road. He studied the relations between humans and nature via costs to nature of industrial operations. The work began from socio-tech systems models, then brought nature into the model. Based at the Stockholm School of Economics, Institute of International Business, Eric Trist was the advisor. The study involved twenty major companies and six national governments. Results centered on the consequences to nature of human industrialization. The entire industrial paradigm came to be included in the inquiry. Data was collected showing that human activities were impacting nature at an alarming rate, and that that rate was increasing. The consequences of this were disrupting the workings of natural systems at an alarming rate.

The sanctity of the social managing the technical was slightly destabilized in 1975. The overriding importance of the environmental to all things living became more apparent. Yes, the social was still effectively managing the technical, but the social was seen to fall short in management of itself, and its values. Self-management came to be needed in emerging requirements to manage environmental deterioration in production and products, not just in production technology.

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Environmental science was noting clear signs of a great danger on the horizon for systems of life. An appreciation of nature and natural processes became an important addition to Systems Thinking, an area of research that had launched special systems concerns in 1941 [8]. Many considered this work by Andras Angyal as fundamental to a more general approach to applying Systems Sciences. Angyal demonstrated how, when a system reaches its limits, the parts assume (take over) the whole. This became most apparent in industrial companies reaching the limits to their production and product and seeking business-as-unusual. It was not relevant to governmental agencies seeking better ways to regulate production and product use from business-as-usual. Those developing Information Technology found Angyal's discovery fundamental to leaving hierarchical structures, then moving on from matrix to the nature of network structures.

Some with experience in concern for the context of living systems, e.g., David Hawk, designed and managed a research project into the subject. He began with measures of environmental deterioration, then launched a two-year study of the effectiveness of social regulation in management of the deterioration effects on humans and nature. Most regulation was measured as less effective than had been assumed. Some approaches encouraged higher levels of pollution via defective technology. From this, the study examined the cultural acceptance of pollution from social systems. Widespread values of urbanism had let to acceptance of environmental desecration that supported a rural war with the natural. The technological and sociological needed to be remodeled. The industrial and its products needed to be radically changed. Governments involved in the project in 1977 saw this change as very unlikely. The Chief Scientist of one of the oil companies in the project was even more pessimistic. He presented to the study that, if things didn't change, there would be global climate change.

The forces behind environmental deterioration were found to be the key to moving the evolution of the socio-technical construct to its next level. It needed to expand to include the context of the social and the technological which involved industrialization and the natural environment. A proposal was made to redesign the Newtonian industrialization model, as well as the products that resulted from it. The twenty industrial firms in the study, and the six nations supporting the study, agreed that business-as-usual would lead to no business at all for humans.

Eric Trist was the PhD supervisor of David Hawk during the research. Trist's past work came to be crucial to the project and to presenting its recommendations. He was a strong supporter of expanding the socio-tech systems model to include context. The three-volume research report resulting from the project were presented to OECD. From that presentation, Russell Ackoff read the work, then contacted David Hawk saying this was his dissertation for a PhD in Social Systems Sciences. David had earlier completed his course work with Ackoff. Eric Trist disagreed, arguing that Hawk needed a theoretical amplification of what the research would mean to other researchers. Such an amplification was done and was attached to the three volumes of empiricism that Russell Ackoff had approved. Much trouble occurred with a two-year review of this work, however. The review committee of seven professors wanted the comment about future climate change to be removed, as it was very speculative. A chief scientist of Exxon, who had been in the study, had made a presentation on the Emergence of Climate Change at the end of the study. He showed how this was due to Exxon processes and Products. He offered this research in support of study results.

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The School Dean refused to sign off the work unless "self-regulation" empiricism, consistent with socio-tech principles, was removed. He felt such a suggestion was too close to anarchism. In addition, he saw no relation between environmental deterioration and business. I agreed with him, that he obviously could not see this.

7. 2020: Nature, the System that Manages

The essence of the dissertation was to move from a societal system of legal order to a negotiated order, much like that found in nature, and which happens in the best socio-tech factory examples. Legal order depends on a hierarchy of control, whereas negotiated order depends on self-management at the edges. Negotiated order processes were well beyond Newton's thinking. They made use of Einstein, Hawking and many leaders in Systems Sciences, such as Rapaport, Vickers, Ackoff, Trist, Boulding, Beer, Cowen, and Ozbekhan. The question here thus becomes: what is a socio-technical system and how does it relate to the natural order of existence? Is socio-tech an attitude towards why and how humans come to relate to the technology they create and come to depend upon? The construct of socio-tech emerged from the work of Eric Trist, et al, as did concern for The Social-Technical-Natural.

2019 A FOREWORD ON THEN AND NOW

"Then was 1979. Now is 2019. In what follows much comes from then, with a touch from now, and concern for those who must occupy tomorrow. Normally, with a forty-year gap in an endeavor, the back-then serves as a baseline. Success can thus be measured in managing the initial concern. From this we can propose measures for improving success. Such a proposal will not be found here. There has been no success in applying findings of concerned company and government people forty years ago. They saw an urgent need to control environmental deterioration resulting from human activities. They helped recommend a new model for regulation. The situation was fluid, not fixed, and in need of ideas for business-as-unusual in both private and public organizations. Back then it was shown how deterioration was expanding and efforts to regulate and limit this impact were turning bad into worse.

The situation of environmental deterioration can no longer be addressed via expanded research, invention of new technologies or more threatening regulations. We need to modify the meeting of humans needs and wants, but not via trivial adjustments to the current neo-classical economic model. We have moved beyond those somewhat understood traditional responses. The consequences of expanding environmental deterioration are significant. Such is now culminating in the dire phenomena briefly mentioned in the 1977 study, called *climate change*." [9, the book can be found in Amazon's Humor Section]

8. Acknowledgements

Eric Trist, Russell Ackoff, Hasan Ozbekhan, Carl Sagan, Yongda Yu, Tsien Hsue-shen, Nicholas Georgescu-Roegen, Richard Garwin, Anatole Rappaport, Sir Geoffrey Vickers, and Stafford Beer.

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[7] John Brunner, "*Shockwave Rider,"* 1975. Brunner's hero's developed computer hacking skills to evade a dystopian future. The book coined many hacking terms, e.g., "worm" that describes a program that propagates itself throughout network. He introduces the concept of Delphi pools, derived from Hasan Ozbekhan when while working at RAND Corporation. He was then a professor, Wharton School, U of Pennsylvania.

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[9] David L. Hawk, *Too Early, Too Late, Now what?* AuthorHouse: Indianapolis, Indiana, 2019, from the Introduction. The republishing of Hawk's thesis, University of Pennsylvania, 1979. The Dean of the Wharton School objected to the document, *Regulation of Environmental Deterioration.*

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