## Calvin Pava
### *Sociotechnical Systems Design for the "Digital Coal Mines"*

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**Abstract**

Calvin Pava made an extraordinary contribution to the future of work design and organizational change in the 21st century. He reconceptualized traditional STS methodology for nonroutine work analysis and design as the design of deliberations and discretionary coalitions focused on collaboration among disparate people where tension, disagreement, and conflict improve the value of the ideas, expose the risks inherent in the plan, and lead to enhanced trust among the participants. Pava provided us with a model for a flexible and scalable organizational architecture based on the precepts of self-regulation; it is a template for combining and integrating self-managing work teams (routine work), project teams (hybrid work) and discretionary coalitions (non-routine work) into a "network" organization. He also recognized that our increasingly turbulent environment requires viewing organizational change less as an event and more as an ongoing dynamic of iterative design.

Pava's work in the 1970's and early 1980's is also an especially effective fit for the 21st century and a digital era that requires tapping into networks of value, connecting information sources, and bridging internal as well as external boundaries. He foresaw addressing more complex problems with sociotechnical design enhanced by information and communication technology leading to more robust solutions. But Pava also recognized the dilemma advanced technology posed: it could be designed for the flourishing of mankind or to manipulate people

and engender passivity in the rest of society, and he strongly warned us to exercise organizational choice in order to disobey the new digital technocratic imperative.

***Key Words***

Sociotechnical Systems Design, Non-routine Knowledge Work, Deliberations, Discretionary Coalitions, Technocratic Imperative

## ***Introduction***

The origin of Sociotechnical Systems Theory (STS-T), Design (STS-D) and Change (STS-C) can be traced to the Haighmoor coalfield in post-World War II England. Social scientists from the Tavistock Institute, Eric Trist and Kenneth Bamforth (1951) observed work systems in the coal mines that incorporated new long wall technologies with the pre-mechanized, semi-autonomous teams of coal miners, and that produced both positive economic outcomes and quality of working life. These innovations in British coal mines served as the genesis for the emergence of a new paradigm of work and work design. Over the next several decades, this initial field research spawned a groundbreaking theoretical framework, robust workplace design and organizational change methodologies, and numerous high profile case examples in the UK, Norway, Sweden, USA, Canada, Australia, and India.

Trist (1993) further claimed that what he and Kenneth Bamforth observed in the coal mines demonstrated that organizations could choose to "disobey the technological imperative" which presumes that people and organizations are seen to be serving the requirements of a technological system that implicitly treats people as a means to an end, and in the process, shapes their purposes and their work (Chandler, 1995). In stark contrast, a central precept of sociotechnical systems theory and design is the joint optimization of both the social and the technical subsystems.

Fast forward to the new millennium and we are facing an even more pervasive technocratic imperative in the form of digitization, microprocessors, and advanced information and communication technologies (ICT). In similar fashion to how the engineers who developed new coal extracting technologies altered that work system, work in contemporary organizations is being dramatically shaped by people with titles such as systems analyst, chief information officers, software engineers, enterprise architects, and application engineers. In a very real sense, they have become the de facto organization designers of the 21st century. We are confronted with a metaphorical "Digital Coal Mine" and an urgent need for theories and methods that will allow us to once again, exercise organizational choice and disobey the technological imperative with positive economic as well as human results (Trist, 1993).

Herein lies what may prove to be Calvin Pava's most significant contributions to STS-D and STS-C, and more broadly the field of organizational change. 35 years ago, Cal provided the foundation for the STS design of the "digital coal mines" with his book, *Managing New Office Technology: An Organizational Strategy* (1983a). Pava was remarkably prescient regarding the potential impact of microprocessors and related technologies on the emerging world of non-routine knowledge work. His influence on the theories and practices of STS-D, STS-C, and organizational change would arguably have been much more significant had he not passed away at a very young age. In fact, we believe that the full impact of his contributions to the design of knowledge work systems is yet to be realized.

Trist (1983) observed that what was happening was *"part of a wider revolution centered on the microprocessor which, during the present and subsequent decades, will establish an information society in the midst of the older industrial society"* (p.164). Pava recognized both the implications of the structural change from an industrial to a post-industrial economy and the potential of ICT to fundamentally transform jobs, the nature of work, the workplace, organizations and even the dynamics of how they change … from routine work systems in which people typically made things to non-routine knowledge work systems in which people increasingly manipulate data and information in order to advance knowledge and create value.

In Pava's view, the digital revolution presented such a challenge that neither the purely "soft" approaches of behavioral science or the "hard" approach of industrial engineering could engender and sustain organizational learning and change as did the unique approach of STS, which had already proven to *"more effectively organize in the most uncertain steps of the conversion process and at the most problematic interfaces with a system's environment"* (Pava, 1983a, p.16). While STS theory and principles are arguably still relevant, the practice and methodologies of traditional STS-D and STS-C did not keep pace. In fact, Pava (1986a) argued forcefully that to ensure ongoing relevance and value, STS design concepts and methods themselves needed to be redesigned. Pava addressed this discontinuity and developed a STS-D approach to address the:

1. Structural shift from routine work in the industrial era to non-routine, knowledge work in the post-industrial era;
2. Fundamental unit of knowledge work which he identified as deliberations and the key elements in the design of deliberations;
3. Dynamics of nonsynoptic systems change (Pava, 1986b) in a turbulent or volatile, uncertain, complex, and ambiguous (VUCA) environment (Stiehm & Townsend, 2002) and the necessity for continuous STS designing;
4. Scalability of deliberation design from teams to organizations to domains which are currently described as networks and ecosystems; and
5. Impact of microprocessors on work and the potential implications of a new version of the technocratic imperative.

Before we discuss Pava's realized, and yet to be realized, contributions to the field of organizational change, and the subsequent research and practice his work stimulated, as well as his "unfinished business", we would like to share Cal's story as it has been relayed to us by his sister, fellow doctoral students, graduate school faculty, Harvard's colleagues, his mentor's spouse, and his friends (Pava, M., 2017; Trist, B., 2017; Winby, 2017; Posey, 2017; Rankin, 2017; Gilmore and Hirschorn, 2017). His prophetic insights regarding the world in which we now work and live beg the questions: what and who shaped his thinking almost 40 years ago.

***Calvin Harmon Peter Pava's Story***

Cal Pava was born in 1953 in Chicago and he grew up during a period of dramatic change in all aspects of society - the Vietnam War, the Beatles, John F. Kennedy's assassination, the civil rights movement, Woodstock, the gay and lesbian rights movement, and the moon landing. Mandy Pava (2017), Cal's older sister, told us that her parents had a hard time prying the then 15-year old Cal away from Stanley Kubrick's 1968 film, *2001 Space Odyssey*, an epic film about the history and future of mankind and its relationship to technology. This certainly foreshadowed Pava's passionate interest in the role of technology and its impact on society, our organizations, and the people who work in them.

Mandy disclosed that Cal did not have many friends growing up, but that he had a very strong relationship with an aunt who was a Northwestern University graduate and member of The Phi Beta Kappa Society. She encouraged him to read widely in order to develop a keen understanding for other viewpoints. Her guidance led to Pava's later commitment to intellectual rigor (M. Pava, 2017). Pava attended New Trier Township High School in Northfield**,** Illinois where he was active on the debate team. He graduated in 1974 from Colgate University which had a strong liberal tradition with a BA in Systems Theory and Social Science.

Cal pursued a doctorate in advanced systems planning design at the Wharton School of the University of Pennsylvania. He participated in the innovative “S-cubed” program, Social Systems Sciences, that operated as a department of the Wharton School at the University of Pennsylvania from the early 1970s through the mid-1980s. The program's founder, Russell Ackoff, had become increasingly critical of Operations Research’s reliance on specific mathematical techniques. So, he launched S-cubed as a multi-disciplinary, functional approach to problem-solving (or preferably problem “dissolving"). S-cubed also attracted other prominent social theorists such as Fred Emery and Eric Trist who contributed additional principles such as synthetic (as opposed to analytical) reasoning, broad stakeholder participation in decision making, and idealized design.

Pava engaged with several key change theorists in this Wharton program such as Eric Trist, Tom Gilmore, Larry Hirschhorn, Don Schon and Jay Galbraith. He was also influenced by his dissertation chair, Hasan Özbekhan, a Turkish-American systems scientist, cyberneticist, philosopher and planner. Özbekhan applied systems theory to global problems in a paper for the Club of Rome, entitled The Predicament of Mankind, which addressed issues of energy, overpopulation, depletion of resources and environmental degradation. We see these seeds in Pava’s novel approach to coping with our human predicament -- namely, of organizing our vision at a higher level through a dialogic process of different points of view where new approaches and attitudes might begin to acquire a degree of immediate relevance. Cal completed his doctorate in 1980. His dissertation, *Towards a Concept of Normative Incrementalism (1983a)*, was an early conceptualization of his organizational change theory, a theory that favored being impactful with short term goals in the present world, while at the same time, through action research, contributing to long term goals of moving gradually towards a more just society.

A Wharton colleague remembers Cal as playful, creative and always in overdrive in terms of his physical and mental energy. Mandy shared stories of her almost 6 foot 5-inch brother with flowing long hair, roller skating through airports with friends. But only a few were privileged to see this side of Cal; to most he was distant, or as many people described him, a very private person with brilliant ideas.

Eric Trist undoubtedly had the greatest influence on Cal’s thinking regarding organization design and change. Pava honed his intense interest in social change theory under the guidance of Trist whom he described as a mentor of “great rigor, vision and compassion” (1983a, p.xi). Much of Cal’s early writing addressed issues that clearly reflected his mentor’s research interests including quality of working life (Pava, 1977; 1979b) and autonomous work groups (Pava, 1979a). Another central tenet of Trist’s thinking that Pava adopted and extended was the issue of organizational choice in the face of the technocratic imperative. Beulah Trist (2017) described them as being of “like minds”. Eric shared with the first author that Cal was his best doctoral student (Austrom, 1984).

Theirs was a remarkably close relationship that was grounded in their shared intellectual passions, but extended well beyond. In a memoir on Eric Trist, Richard Trahair noted that “Cal Pava had a special place in Eric’s heart” (2015, p. 309). When Eric was informed that Cal was in the last stages of dying from an incurable tumor, he insisted on visiting him in the hospital even though he was himself in a weakened state. Stu Winby, a mutual friend, drove Eric to the hospital. When they arrived, Stu said “Cal, Eric’s here” and even though Cal did not open his eyes, he responded with a huge smile (Winby, 2017; Trahair, 2015).

From 1978 to 1981, Pava taught telecommunications at New York University, where he also helped create a master’s degree program on integrating telecommunications and computers. In 1982, Pava was hired as an Assistant Professor at Harvard Business School in its recently established multidisciplinary program on human resources in organizations. Paul Lawrence, a renowned sociologist and one of the world's most influential and prolific scholars in the field of organizational behavior, was a close colleague and mentor to Cal while he was at Harvard. Lawrence reinforced Pava’s view that research should ultimately be centered around an important and managerially relevant problem. Pava and Lawrence shared the belief that it was the responsibility of researchers to shed light on the management issues of the time (Lawrence, 2011).

While at Harvard, Pava authored several papers (1982; 1983a; 1985; 1986a; 1986b) and co-authored two series of case studies with John Mayer (1985a; 1985b; 1985c; 1985d; 1986a; 1986b; 1986c; 1986d) about the design of organizations that reflected in part, the influence of his

Harvard OB and HR colleagues, notably John Kotter, Dick Walton, Mike Beer**,** Jeff Sonnenfeld, and John Kao. In 1982-1983, Cal also participated in the *White House Conference on Productivity* (1984) with Stu Winby. Winby (2017) reports that Pava convinced the CEO of Apple, John Sculley, to provide 200 recently released Apple II computers so conference team members could work virtually as well as face-to-face. This is yet another example of how forward-thinking Cal was regarding the possibilities of microelectronics and computer technology.

In 1986, Pava was diagnosed with a brain tumor. He relocated to California in 1987 primarily for medical treatment, and secondarily because of his professional interests in technology. When the tumor was in remission, Pava consulted with high-technology companies as a partner in Cole, Gilbourne, Pava & Arioshi, a venture capital firm specializing in new technology companies. Cal's clients included technology leaders such as Apple Computer. and Intel. The focus of his work was on organization design, strategy implementation and entrepreneurial business strategy.

Cal Pava passed away in 1992; he was only 39. When we consider that Pava lived and made his contributions to the field of organizational change over 30 years ago -- prior even to the advent of the internet -- his foresight regarding both the potential benefits and downsides of technology were quite remarkable. Pava generated a grand vision for a future of work enabled by advanced technology, but grounded in humanistic ideals, hope and optimism. Throughout his short life, Pava was a restless intellect in search of big ideas about humanity. He marched to the beat of his own drum and had little patience with those who did not have the same foresight.

**Pava's Key Contributions to Change Theory**

Given his early influencers and the intellectual tradition he embraced, Cal Pava's work on organizational change was grounded in open systems theory and more specifically, sociotechnical systems (STS) theory and design. Open systems theory is based on the concept that organizations are strongly influenced by their organizational environment which consists of other organizations that exert various forces of an economic, political, or social nature. Emery and Trist (1973) described the organizational environment of the latter half of the last century as turbulent.

Much of this turbulence was due to the structural transformation underway in the developed world that Drucker (1959) foresaw in the 1950's and Bell articulated in 1973, from an industrial to postindustrial society. Post-industrial society has effectively replaced industrial society as the dominant organizing system. As Drucker (1959) and then Bell (1973) predicted, much of our economic activity has been transformed from manufacturing to services and information-based industries. The task of work systems in postindustrial society has shifted from relying on fabrication activities and the division of labor to information activities, with an emphasis on knowledge processes involving intellectual technologies, human interaction, and networked labor (Bell, 1973). Virtually all these earlier predictions have come to pass, even more profoundly than we could have imagined four, let alone six, decades ago. We have witnessed rapid automation of manufacturing in North America and Europe and a dramatic shift to highly-compensated knowledge work in information and knowledge-intensive workplaces and to modestly-compensated work in the service industry.

The practice of STS design from the 1950s through the 1970s reflected the predominant workplaces of that era, process and manufacturing industries. Work processes tended to be highly routine and the basic unit of work analysis was the work group rather than the single job and the individual job holder. STS viewed the individual as complementary to the machine rather than an extension of it. STS design focused on developing multiple skills in the individual to increase the response repertoire of the group (redundancy of functions), the discretionary rather than prescribed part of work roles so that work was variety-increasing for both the individual and the organization rather than variety-reducing as in the bureaucratic mode, and internal regulation of the system by the group versus external regulation of individuals by supervisors.

However, by the late 1970’s and into the 1980’s, there was increasing concern that STS design had fallen into a conceptual rut. Tom Cummings (1978) argued that STS’s shop-floor heritage and its language, concepts and orientation, limited its application in office settings. He also claimed that at the time the relatively lower reliance on technology in the office created an imbalance between the social and technical systems, and rendered the analytic tools less useful. Eric Trist (1983) and Cal Pava (1986a) shared these concerns and claimed that STS design’s over-reliance on traditional practices such as the nine-step method and self-managed teams had stifled innovation and restricted STS’s applicability to the emergent workplace.

As opposed to routine work such as manufacturing, in which the conversion processes were linear and the steps were reasonably predetermined, non-routine work systems such as research and development, market research, managerial and professional work to name a few, involve a high degree of equivocality in their nonlinear conversion processes. Given this emerging reality, Pava observed that these conditions invalidated the key assumptions of conventional STS design such as definable inputs and outputs, sequential conversion, cascading one-way variances, and pooled group identity. Pava addressed the challenges of applying STS theory to the design of non-routine work systems in 1983 with the publication of his seminal work, and only book, *Managing New Office Technology: An Organizational Strategy* (1983a).

**Fundamental Shift in the Nature of Work**

Knowledge work involves non-routine problem solving that requires a combination of convergent, divergent, and creative thinking (Reinhardt, Schmidt, Sloep, & Drachsler 2011). It is typically non-repeated, unpredictable, emergent and primarily involves the management of unstructured or semi-structured problems (Keen & Morton, 1978). It is characterized by imprecise information inputs, varying degrees of detail, extended or unfixed time horizons, dispersed information formats, and diffuse or general scope. Pava (1983a; 1986a) and Pasmore and Gurley (1991) articulated the key differences in the changing nature of work between the industrial and post-industrial eras. See Table 1. Given the salient characteristics of the emergent work systems, non-routine knowledge work was not amenable to traditional methods of sociotechnical analysis. As Pava (1983a, p. 130) argued:

> *A strictly sequential chain of steps either simply does not exist or fails to capture the essence of such work. Also, the constellation of individuals needed to run non-routine work is always shifting, depending upon changing circumstance, while social analysis emphasizes discrete roles and their accumulation of satisfying features.*

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**Insert Table 1 about here**

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Pava (1986a) further argued that the shift from long-linked mechanical technologies to integrated information processing technologies and changing nature of work because of this technological transition necessitated an overhaul in STS design of work systems. This is critical because a central concept of STS Theory and Design is joint optimization; that organizations will function most effectively if the social and technical subsystems are designed to optimally fit the demands of each other and of the environment (van Eijnnatten, Shani, and Leary, 2008). But as

Pava observed, in knowledge work it was becoming increasingly difficult to discern the elements of the technical and social subsystems since both were related to people.

**Deliberation Analysis and the Design of Non-routine, Knowledge Work Systems**

Pava recognized that while analysis of the technical and social subsystems was still needed in order to design the best match between subsystems, the basic unit of analysis needed to be transformed (Pava, 1983a; 1983b). Pava identified deliberations as the basic unit of analysis in non-routine, knowledge work which he defined as:

> *… reflective and communicative behaviors concerning a particular topic. They are patterns of exchange and communication in which people engage with themselves or others to reduce the equivocality of a problematic issue* (Pava, 1983b, p. 58).

Pava (1983a) further described deliberations as choice points that are critical to work systems involving knowledge generation and knowledge utilization. Pava emphasized that deliberations were not just meetings, conversations or decisions. Rather deliberations encompass all activities that advance knowledge. They include a constellation of knowledge generation activities from people working independently – for example, collecting and analyzing data, eureka moments in the shower or commuting to work, documenting reflections, research findings, insights, and personal positions – to people working collectively – for example, work groups, teams, departments, functions, cross-functional task forces, local offices, virtual research projects, town hall meetings, supply chains, networks, and more recently, open source initiatives, platforms, and business ecosystems. The interactions can range from informal and unstructured hallway conversations to highly structured and formal gatherings for relationship building, information sharing, discussion, debate, dialogue, and decision-making.

Deliberations form a collectively built framework that creates clarity without denying complexity. Rather than ignoring or minimizing the complexity of nonlinear conversion processes, deliberation analysis provided STS researchers and practitioners with a way to trace the sequence and type of deliberations. The key elements of this non-routine knowledge work conversion process are shown in Figure 1. The inputs to deliberations consist of the **topics** -- problematic issues, innovation tasks, or novel events -- to be addressed, the **forums** in which they occur, which may be structured, semi-structured, or unstructured and ad hoc, and the **participants** with specific points of view, both those who are currently involved and those who ideally should be involved in the deliberation.

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Pava described the social subsystem in terms of the **discretionary coalitions** or flexible alliances of interdependent parties formed to make intelligent trade-offs that enable attainment of the best outcomes based on the inputs of people with inherently divergent values and perspectives. Deliberations often cut across formal departmental boundaries and involve informal patterns of exchange, specific to the topic under consideration.

Discretionary coalitions are to non-routine work what work groups or teams are to more routine work. This was, and still is, a novel organizing principle because it overlays or pushes the static positions of the organization chart into the background. Unlike routine STS-D, deliberation analysis emphasizes reciprocal understanding rather than a shared goal and shared group identity as one finds in self-managing teams that tend to be more permanent entities in the social system.

The outputs of deliberations include any outcomes that contribute to the advancement and application of knowledge. This can be both tangible outcomes such as decisions, commitments to action, and agreement as well as disagreements, which may or may not be documented. The outputs of deliberations can also be less tangible, but no less important; for example, new perspectives, new insights, and an expanded pool of shared knowledge. Identifying major deliberations and the discretionary coalitions needed to manage them helps gain better alignment between the major lines of contention and the overall viability of an enterprise in a turbulent environment.

In terms of Pava's contribution to the field of organizational change, it is important to mention the implicit and explicit linkages between STS theory, STS design, and STS change and development processes (Pasmore, 1988; 1994; van Eijnatten, Shani, and Leary, 2008) and further note that STS theory typically serves as the conceptual foundation and guide for both STS design and STS change (Stebbins, 2003; van Eijnatten, Shani, and Leary, 2008). In keeping with this tradition, Pava adhered to the core tenets of STS theory and design. Specifically, he based his design of non-routine work on the principle that organizations are open systems that interact with a complex environment (transactional and contextual) and transform inputs into outputs via a sequence of conversions, emphasize redundant function over redundant parts, can self-regulate many of its own activities through feedback without excessive supervision because of shared goals, generate a level of variety that matches the level of flexibility required to achieve its purpose in its environment, and seek an optimal match of the social and technical subsystems.

Furthermore, Pava reinforced the STS principle that the design process is as important as the design product and that it must be self-designing because only the participants in the "system" can determine its nature, purpose and boundaries before designing its details. The participative design approach itself is a prototype of the managerial style required to realize the benefits of a STS design for non-routine knowledge work. Finally, the design process is based on the principle of minimal critical specifications, where only those things that must be defined are and the process is open-ended because it must adapt the design as changing circumstances make the existing design obsolete.

Pava developed a multiple-step approach to the STS design of non-routine knowledge work systems: mapping the client system; structuring the client's capacity for participative design; performing an initial scan; analyzing the technical subsystem; analyzing the social subsystem; generating and implementing design recommendations. Additional detail on the main activities in each step of Pava's non-routine work system design is provided Table 2.

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**Insert Table 2 about here**

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Though the underlying theory, design principles and the nomenclature of the steps are essentially the same, the analysis of the technical and social sub-systems vary considerably from the approaches used in the first generation of STS-D, especially the shift from a social subsystem based on self-managed work groups with interchangeable skills to discretionary coalitions. These often unprogrammable coalitions were an early precursor to what we now describe as project-based or network organizational structure. And while Herbst (1976) had recognized networks and matrices as an alternative form of nonhierarchical organizations beyond autonomous work groups, he lacked the concept of deliberations and discretionary coalitions as the basis for the analysis and design of dynamic network enterprises (Trist, 1983).

**Pava's Research Program**

Pava's research program could best be described as grounded theory building using case methodology and the principles of action learning as described by Morgan and Ramirez (1983). But it is important to consider the time span of Pava's research program: he completed his dissertation in 1980 and published his last articles in 1986, the year he was diagnosed with a brain tumor. During that six-year period he wrote several scholarly articles, published his book, and co-authored several HBS business cases.

Prior to, and in the early stages of his illness, Pava consulted with both the producers and users of advanced technology who were encountering problems of maintaining effective organizations under conditions of increasingly turbulent change. His most illustrative cases of the application of deliberation analysis included the software engineering group in a moderate-sized computer systems firm (1983a) and the customer service and support unit in a rapidly growing microcomputer device company (1986b).

In the case of the microcomputer device company, management had decided to install a new computer system. However, they were not convinced that the recommended systems requirements would achieve the desired levels of customer support. An STS design effort was initiated and business, technical, and social analyses were conducted. The design team proposed that the customer support unit be reorganized into market team structure. Six regional support teams were established to provide full line service and to acquire customer and market data for their region. There was a modest amount of cross-training and a moderate degree of job enrichment along with a pay-for-skill ladder. All would be shared with the team first. At the end of the first year, customer satisfaction had improved significantly and the teams had achieved unexpectedly high scores on the performance measures they had jointly established during the redesign.

**1980's -- Pava's Contemporaries on Non-Routine Work Systems**

The office of the future, the impact of information technology and the changing nature of work in an information economy received increasing attention during the late 1970's and early 1980's from policy makers and researchers (cf. Uhlig, Farber, and Bair, 1979; Russell, 1981; Tapscott, 1982; Walton, 1983; Walton and Vittori, 1983; Baetz, 1985) as well as STS-D practitioners (cf. Taylor, 1982; Taylor, Gustavson, and Carter, 1986; Painter, 2015). Taylor, Gustavson, and Carter (1986) applied STS-D and STS-C techniques in a non-routine knowledge work system with the engineers in a product development group. The focal technology was computer assisted design (CAD). This case is noteworthy because the design occurred both prior to and while Pava was developing his model of deliberation analysis and design. Even so, the STS design team in this case analyzed work-related interactions in the system including who talked with whom (discretionary coalitions) for what reasons and about what kinds of issues (topics). They also made recommendations such as monthly meetings (forums) with affinity teams to share information and upgrade each other's skills. Tellingly, the design team came to the realization that the product of the engineering group was information; information that was used to manufacture, test, and market the products.

Also in the early 1980's, the second author of this paper discovered the limitations of traditional STS when doing greenfield plant design with GE Aviation's Bromont site in Quebec. While the traditional STS methodology worked well for the primary work system design, it did not fit the management, professional, and administrative work systems. The primary tool for analyzing the social system employed by STS practitioners at the time, and the one that Taylor and colleagues (1986) also used, was Parson's AGIL model (Parsons and Smelser, 1956). The acronym stands for adaptation (A), goal attainment (G), integration (I) and latency (L), or as it is more typically described, culture. Using this model, and the plant's philosophy of participative management, the design team defined four areas of work that needed continual resolution by all plant staff:

1. How to adapt automation and robotics technology (A);
2. How to compete for new contracts to maintain plant viability (G);
3. How to continually maintain a sense of community and wholeness among a diverse set of internal relationships and external relationships with its supply chain, GE Aviation, and GE corporate (I); and
4. How to maintain a system of justice and fair treatment for all in a continuously changing environment (L).

Standing councils were formed around these four topics and all employees rotated through these councils by their own choice on a regular basis so that all points of view were heard on these four vital topics to plant sustainability long-term. When Pava's book was published in 1983, this author realized that the four topic areas were, in fact, deliberations and that the Councils with rotating members were a form of discretionary coalition. Pava crystalized for the author the realization that non-routine design work at the organization and domain levels is about translating the abstractions of vision and strategy into operational design principles; in other words, reducing the equivocality. Pava (1986a) saw clearly that managerial and professional work in the future would entail continuous dynamic design, integrating purpose, vision and strategy constantly with the primary work system and the non-routine work of organizational learning. This author further realized some of the shortcomings of the participative management approach; that is, it’s implicit emphasis on team harmony. In stark contrast, Pava explicitly proposes structured, productive conflict based on the willingness to challenge and debate each other’s ideas in an environment that encourages diversity and mutual respect. In the design of the social system, the participants in the discretionary coalitions are chosen to optimize different points of view and values orientations, specifically harnessing both wild imagination and pragmatism that together recognize points of unity and contention and drive to new levels of convergence.

This author then applied this non-routine work design with the site management and professional staff to connect their efforts more tightly and strategically with the primary work system design, experimenting with prototypes that enabled sustained interactions between management, professionals and primary work system staff and external partners for a common purpose. Her clients recognized that when each party manipulates others to meet its own needs without regard to the needs and values of the others, it created an incoherent mess. By regarding conflict as an opportunity or set of constraints, and not as an impasse, their creativity was more effectively engaged to build collective intelligence. GE Bromont’s innovative organization and work system design continue to be one of the longest-standing exemplars of STS-D.

**1990’s to the Present -- From Variances to Knowledge Barriers**

In traditional Tavistock-North American STS-D and STS-C, there was considerable focus on the analysis and control of variances in work flow. Variances were defined as significant deviations from routine process performance. However, Ron Purser and colleagues (cf. Purser, 1990; Purser and Pasmore, 1992; Purser, Pasmore and Tenkasi, 1992; Pasmore and Purser, 1993) made a convincing case that variances in non-routine knowledge-work systems actually manifest as knowledge barriers -- that is, any factor that inhibits or undermines the generation of new insights and new knowledge in timely fashion.

Purser (1990) conducted a STS analysis of a non-routine work system in a research and development function of a major corporation. He used both quantitative methods and qualitative methods – surveys and observations -- to analyze key deliberations and discover the critical variances that contributed to delays on research projects. Purser observed that delays occurred when there was a lack of critical knowledge or information to make decisions, when there was inadequate time to make thoughtful decisions, and when information was missing due to poor documentation of previous projects. Based on factor analysis of these variances or barriers to knowledge creation and utilization, Purser, Pasmore, and Tenkasi (1992) identified four main categories of barriers obstructing and delaying collaborative knowledge development: lack of a common frame of reference, failure to share knowledge, lack of knowledge, and failure to use knowledge. See Table 3 for a description of the four categories of knowledge barriers.

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Purser et al (1992) determined that these knowledge barriers were due to poorly designed and mismanaged deliberations. To improve deliberation efficacy and ensure that relevant parties are involved in key deliberations and that they have a common lexicon, and adequate time, Purser and colleagues offered the following recommendations:

1. Align the most useful skills of participants with the various deliberations.
2. Ensure that reward systems foster knowledge sharing.
3. Implement a participative learning system.
4. Allocate sufficient time for learning in the early stages of product development.
5. Design deliberations that promote knowledge development and learning.

Pasmore (1994) confirmed Pava's earlier work that the differences between variances in routine and non-routine work are so significant that they require new STS thinking; more specifically, that adequate preparation and problem definition are critical so that people can organize themselves to deliberate effectively on the questions they have identified. He also further elaborated the characteristics of effective and ineffective deliberations.

Stebbins and Shani (1995) used deliberation analysis and non-routine STS design comparing two cases: a chemical company's R&D division and a teaching hospital. In both cases, the work systems were comprised of highly educated knowledge workers with significant specialization of expertise and tasks. In both cases, barriers to full utilization of knowledge were identified. Integration groups separate from the hierarchy were created in the R&D division to improve and accelerate knowledge utilization in order to get new products to market more quickly. In the hospital case, parallel learning structures such as study groups were institutionalized in order to strengthen training and improve health care delivery. Based on their experiences with these cases, Stebbins and Shani proposed a set of design principles to guide the design of knowledge work systems. The central theme to their proposed design principles is that knowledge workers must be afforded considerable autonomy in the design of their work systems and in how they utilize the STS-D process and diagnostic methods.

In his book, Pava (1983a) outlined a relatively high level process for conducting deliberation analysis and non-routine STS-D. It was not as fully delineated as the nine-step STS analytical model for routine work systems (Emery, Foster, and Woollard, 1967; Emery and Trist, 1978) nor as pragmatically prescriptive as the nine-step process taught in UCLA's Quality Working Life "short course" on STS-D. The lack of specific tools and templates may be another factor in why Pava's contributions to STS-D and STS-C did not receive wider attention. In the second edition of his book (1999), *Designing a High-Performance Organization*, Bill Lytle added a chapter on "the special case of knowledge work" (1999, p. 237). This chapter provides the most fully developed and detailed description of the key issues involved in the design of knowledge work and the steps in the analysis and design process. He also includes templates for deliberation analysis, specific questions to consider, and a case example. While Lytle still uses the more traditional language of variances, the categories and possible causes of variances that he provides are quite consistent with the knowledge barriers identified by Purser, Pasmore et al.

More recently a team of practitioners from the Sociotechnical Systems Roundtable and researchers from various academic institutions conducted a study on virtual R&D programs as sociotechnical systems (Painter, Posey, Austrom, Tenkasi, Barrett, and Merck, 2016). This study analyzed the deliberations, knowledge barriers, and coordination mechanisms of three virtual R&D projects arrayed along an R&D continuum based on the degree of task uncertainty (Ordowich, 2009; Revkin, 2008). For example, the very early stages of the R&D process (R1 and R2) are characterized by high degrees of task uncertainty; i.e., researchers are unclear conceptually on both what to do and how to do it. At the later stages of the R&D process (D3 and D4), the knowledge development tasks have become more routinized and much less uncertain; i.e., people both know what to do and how to do it operationally. The study also focused on improving our understanding of how collaborative research initiatives can be most effectively coordinated and how knowledge and learning are best managed in virtual work systems.

The research sites included a video game developer in the process of updating a popular video game with suppliers located on multiple continents, a network of 29 NIA-funded Alzheimers research centers creating and implementing a uniform data set, and a DARPA-funded research project based at Cal Tech which involved theoretical and experimental physicists in Germany, Canada, and the United States using light waves to manipulate mechanical devices at nanoscale. To assess deliberation efficacy and identify knowledge barriers in these virtual R&D projects, the study employed Pava's (1983a) diagnostic steps of deliberation analysis.

In general, the findings of this study indicated that the failure to develop, share, or use knowledge is exacerbated by the level of task uncertainty and the degree of virtuality. A high degree of virtuality drove the need to design better coordinating mechanisms to mediate the challenges of working virtually and to address or reduce the resulting knowledge barriers. Findings also included identification of appropriate governance and coordinating mechanisms for effectively managing and supporting virtual work at different stages in the R&D process. Indeed, in each of these virtual R&D projects, effective coordination involved a specific combination of coordination elements and mechanisms. This is consistent with a knowledge-based model of coordination (Kotlarsky et al., 2008) in which different types of coordination mechanisms were found to make different contributions to knowledge sharing and development—organizational structural mechanisms facilitate knowledge flows; work-process mechanisms make knowledge and expectations explicit; technology-based mechanisms amplify knowledge; and, the inter-personal skills and mechanisms associated with people build social capital.

The results of this study suggest that defining common purpose for knowledge generation collaboration can also inform a framework for the coordination of distributed R&D work as an open sociotechnical system. In this regard, there are transaction costs to overcome with multi-university research and globally distributed projects, and a key driver of that cost is coordination (Binder, 2007; Cummings and Kiestler, 2007). Even though there is "a common notion that collaboration technology and bandwidth will [alone] allow a virtual team to perform as if co-located … evidence shows this notion to be a naïve myth" (Moser and Halpin, 2009). Given the dual challenges of virtuality and task uncertainty, the design of the forums in which mission critical deliberations occur is particularly important. Results of this study indicate that ill-formed and important deliberations are best addressed in-person and not electronically-mediated forums. For example, in the Cal Tech project an embedded researcher, a post-doctoral fellow from Germany, was able to provide a serendipitous connection with his German theoretical physicist colleagues that led to a breakthrough interpretation of perplexing results that the experimental physicists at Cal Tech had recently produced.

A secondary goal of this research study was to translate the research findings into grounded or evidence-based practice and to use the insights to design more effective and efficient knowledge work systems in both virtual and co-located contexts (Austrom, Posey, Barrett, Merck, Painter, and Tenkasi, 2015). To that end, Posey, Painter and Merck developed, and piloted with a national research laboratory, a participative workshop for designing governance systems and coordination mechanisms that strengthen deliberation efficacy and mitigate knowledge development barriers in R&D and innovation work. Specifically, the lessons for practice and consulting from this study were translated into a four-step design process that can be used to better design knowledge work. The four steps include:

1. Locate the project or work on the R&D-Innovation (task uncertainty) continuum;
2. Identify the key deliberations;
3. Identify and analyze existing and potential knowledge barriers; and
4. Determine the appropriate governance system and optimal coordination mechanisms.

Once the location on the continuum is determined, the key deliberations identified, and the specific knowledge development barriers analyzed, the barriers can be mitigated with participative design of specific types of coordinating mechanisms that best fit the stage in the R&D continuum. At the end of the continuum where uncertainty is high, coordinating mechanisms that involve informal and formal mutual adjustment are most effective at mitigating the knowledge barriers. These mechanisms are designed primarily from social subsystem interactions and include interventions such as facilitator and leadership roles, site visits, embedded observers, and even temporary co-location. At the other end of the continuum, uncertainty is quite low and the coordinating mechanisms tend to stem from the technical subsystem. At this point on the continuum, coordination is best achieved through the participative development of common procedures, plans and standards, such as data formats, standardization of processes, error-tracking procedures, and common mission and goals.

Locating one's work on the R&D-innovation continuum can help practitioners to anticipate the general degree of their coordination challenge and the type of coordination mechanisms that are likely to be most important in mediating barriers to successful collaboration in virtual settings. Then, STS analysis of deliberations and knowledge development barriers can provide practical insights to inform the design of more specific methods of coordination. But as Pava (1983a) observed, the STS design of coordination mechanisms and deliberations for virtual organization is not simply a mechanical extrapolation from prior analysis; it is a creative synthesis informed by deliberation analysis. Nevertheless, the elements that are the ingredients for the options of 'when', 'where' and 'how' to effectively coordinate work such as virtual R&D can be mixed and matched from the palette of a sociotechnical systems framework.

**From Episodic STS Design and Change to Continuous STS Designing and Change**

Pava recognized that a key challenge for management was how to foster organizational learning and continuous organization designing within a holistic, self-designed organizational architecture. This was needed, not only to enhance the functionality of the technology itself, but also to take advantage, in a world more subtly connected and faster paced, of the business opportunities available which happens "as employees accommodate to the system in a context of ongoing organizational restructuring" (Pava, 1983a, p.8). His thinking regarding the nature of organizational change – from episodic to continuous designing and change -- foreshadowed emerging models of organizational change (cf. Pasmore, 2015; Kotter, 2015).

Pava (1986b) articulated a contingency framework that provided a pragmatic approach to managing change in managerial and administrative work on an almost daily basis. His approach matches variable conditions of change with alternate strategies. Pava identified two conditions that needed to be addressed to ensure the type of change strategy adopted would be viable: the social which entails the degree of conflict between different parties and the technical which encompasses the level of complexity in the conditions that must be altered. Based on these two factors, he described four types:

1. Master Planning – low conflict and low task complexity – typical corporate strategic planning;
2. Incremental Planning – high conflict and low task complexity – voting, bargaining;

3. Normative Systems Redesign – low conflict and high task complexity – idealized design; and
4. Non-Synoptic Systems Change – high conflict and high task complexity – more like a quest than a strategy where all contributors are informed and highly "change-aware".

Pava viewed continuous organization designing as an ongoing journey that must be orchestrated initially by management so that it is self-directed change involving the whole enterprise – teams, organizations, networks, and ecosystem. This dynamic organization designing is the capacity to act, react and ideally pro-act as technological and societal changes accelerate. Pava recognized that with ever-growing interconnections and speed of interaction, there would be ever-greater polarization and that *factions of every kind, such as professions, political interests, and organizational units, find it progressively harder to cooperate* (Pava,1983b, p. 12). He predicted this would intensify maneuvering for exclusive gain wherever people had to adapt to change, but especially where the introduction of new technology would work against the degree of collaboration needed for innovation.

Pava's articulation of nonsynoptic change methodology coupled with deliberation design appears to be an especially effective fit in a VUCA or turbulent environment which involves adapting to continuous change and requires tapping into networks of information, connecting the dots of information, and bridging internal as well as external boundaries. Pava recognized that a crucial challenge for future success was to focus on the essential design questions or deliberation topics: what do you want to achieve, why do you want that, how do you get there, who do you need, and how are you going to gauge whether you achieved desired outcomes or not? Regular deliberations on these questions and topics ensure continuous learning and awareness of the environment. Further, achieving requisite variety (Ashby, 1956) in a VUCA environment necessitates discretionary coalitions with a diversity of people and diverse points of view.

This is consistent with McCann's and Selsky's (2012) notion that an adaptive design mindset at the individual, team, organization, and ecosystem levels is critical to achieving the agility and resilience necessary for achieving superior performance in a hyper-turbulent environment. Their model includes critical capabilities such as being purposeful, being aware, and being networked all of which are enacted in deliberations: frequent information sharing of purpose and values, achieving consensus on shared beliefs as the foundation for collaborative efforts, information gathering, filtering, and sharing, collective sense making, strategic knowledge management, shared problem-solving, and actively managed networks of relationships within and between organizations.

**Scaling Deliberation Design: From Teams to Organizations to Networks and Ecosystems**

In our VUCA post-industrial era, ubiquitous information and communication technologies have given rise to a post-corporate economy (Davis, 2017) and a range of temporary (cf. Kenis, Janowicz-Panjaitan, and Cambre, 2009; Lundin, Arvidsson, Brady, Ekstedt, Midler, and Sydow, 2015; Libert, Beck, and Wind, 2016) dispersed, networked enterprise forms, platforms, and business or social ecosystems (cf. Cross and Thomas, 2009; Adner, 2012; Johnson, 2012; Gorbis, 2013; Parker, Van Alstyne, and Choudary, 2016; Ramirez and Mannerik, 2017). As Lundin et al. (2015) argue in their book, *Managing and Working in a Project Society*, work increasingly occurs in flexible projects rather than fixed corporate structures. Pava provided us with a preliminary model for a flexible and scalable organizational architecture based on the precepts of self-regulation. It is a template for combining and integrating self-managing work teams (routine work), project teams (hybrid work) and discretionary coalitions (non-routine work) into a reticular organization (Friend, Power, and Yewlett, 1974).

Trist (1983a) further confirmed in the afterword in Pava's book that the concept of self-regulation was meant to be extended to every system level so that the organization as a whole is seen as a series of mutually articulated self-regulating systems, which would make the enterprise both flatter and leaner. Essentially, Trist was making the case on Pava's behalf that deliberations should be regarded as the common or basic unit of analysis for the purposes of STS design of non-routine work at every system level; teams, organizations, networks, and ecosystems. In short, knowledge work is conducted through deliberations regardless of system level. It is fairly safe to assume that if Pava were still alive, he would have more fully elaborated concepts and tools of deliberation analysis for the STS design of our temporary and dispersed or networked organizational forms.

In fact, many recent models of organizational design and change – at the firm, network and ecosystems levels -- implicitly involve the design of effective and efficient deliberations, albeit with their own terminology. For example, sociocracy provides a system of governance and a template for democratic and distributed decision-making (Endenburg, 1998). And since sociocracy employs a fractal structure, it too is scalable to multiple levels of social system design. In its more recent incarnation, Sociocracy 3.0, is described as "*an open framework for evolving* *agile and resilient organizations of any size, from small start-ups to large international networks and nationwide, multi-agency collaboration"* (Bockelbrink and Priest, 2017). Sociocracy 3.0 claims to achieve collaboration at all these levels based on elements such as coordination circles, focused interactions, effective meeting practices, consent decision-making, artful and representative participation, defining agreements, and principles such as *"those affected decide"*. A case could be made that these principles and practices provide a more contemporary and articulated model of topics, forums, participants, discretionary coalition, and deliberations.

Another noteworthy example is the recently popular holacracy which is described as the revolutionary new management system for a rapidly changing world (Robertson, 2015). Building on sociocracy and agile development, holacracy involves "*a constitution which sets out the "rules of the game" and redistributes authority, a new way to structure an organization and define people's role and spheres of authority within it, a unique decision-making process for updating those roles and authorities, and a meeting process for keeping teams in sync and getting work done together*" (Robertson 2015, 12). Here too, we can see that deliberations and the design of deliberations are central elements of holacratic design. The same observation holds for liberating structures (Lipmanowicz and McCandless, 2013; Kimball, 2013) changing the organization *one conversation at a time* (Kimball, 2013, p.31) and its menu of 33 microstructures that are designed to *enhance relational coordination and trust* (Liberating Structures website, 2017) and provide an alternate way to design how people work together.

A case can also be made that deliberation design is a critically important aspect of current dialogic approaches to organizational change and development; for example, design choices include identifying participants with representatively diverse viewpoints, determining appropriate topics, and creating forums or "safe containers" for open dialogue. A sample of these change methodologies includes search conferences (Emery, 1999; Emery and Purser, 1996), participative design workshops (Emery, 1993), future searches (Weisbord and Janoff, 2010), the conference model (Axelrod, 2010), the meeting canoe model (Axelrod and Axelrod, 2014), design charrettes (Lennertz andLutzenhiser,2006), open space technology (Owen, 2008), world cafés (Brown, and Issacs, 2005), participatory action research (Gustavsen, 1992) and dialogic organization development (Busche and Marshak, 2015). The intent is not to reduce these and other change and design methods simply to deliberation design. Rather it is to point out that the design of deliberations is a critical unit of analysis for the design of an intervention, the change processes themselves and the resulting working relationships.

Dialogic approaches to organization design, development, and change speak implicitly to "changing the fundamental narrative" and the emergence of a new organizing paradigm based on collaboration and mutual adaptation (Perlmutter and Trist, 1986; Heckscher, 2015; Johansen and Ronn, 2014; Nyden, Vitasek and Frylinger, 2013; Morgan, 2012; McAfee, 2009; Heckscher, 2007; Heckscher and Adler, 2006; Mattessich, Murray-Close and Monsey, 2001; Campbell and Gould, 2000) rather than the premises, values, and beliefs of bureaucratic "command and control". In our increasingly interdependent world, collaboration is no longer a choice; it is becoming an imperative for the coordination of collective activity within single enterprises, networks, and business/social ecosystems.

As Charles Heckscher states: *Collaboration, working together in a rich community … takes up the problem of acting together in such a diverse, fluid, open world. This requires a shift from bureaucratic formality to collaboration. Bureaucracy organizes through obedience to rules; collaboration involves continual interactivity, mutual adjustment, and learning. Collaboration seeks to maximize the contribution of diverse people, rather than ignoring their diversity and demanding uniform obedience* (2015, p. viii). Given Pava's (1983a) emphasis on involving participants with divergent orientations in the discretionary coalitions, deliberation design is well-suited to achieving these outcomes in the current era of collaboration, collaborative innovation, business and social ecosystems, platforms, and other forms of networked enterprises,

Given the current importance of collaboration coupled with the exponential growth of information and communication technology (ICT), we have updated Pava's conversion process for non-routine knowledge. The added elements are italicized in Figure 2. In similar fashion to Herbst's (1974) observation that "the product of work is people", we contend that the key outputs or byproducts of well-designed deliberations are increased trust and enhanced capability to collaborate among the participants. As members of discretionary coalitions become more skilled in deliberating and successfully work together to advance knowledge based on "contention, convergence, unity" (Pava, 1983a, p. 103), it is reasonable to assume that they will also be developing "collaborative attitudes and methods" (Heckscher, 205, p. 170). Trust should also grow to a higher and qualitatively different level based on repeated interactions and increased understanding of each other's' values and goals and the recognition of common ground (Lewicki and Tomlinson, 2003).

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**Insert Figure 2 about here**

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Given the accelerating pace of change in our current turbulent environment, the urgency and priority or materiality of the topics to be deliberated have become even more salient inputs in the transformation process. Technology and data analytics have also become profoundly important inputs to the deliberation conversion process. Data, physical documents, other sources of information, intelligent equipment, and ICT were certainly available during the era in which Pava developed his models. But the new tools in the 1980s' office of the future were word processors, integrated voice/data switches, portable computers, and fax machines. In an era of Big Data, analytics, the internet of things, and artificial intelligence or cognitive computing, these and other technology-based inputs must be considered in deliberation design. Enabling technologies such as collaboration software, ICT hardware and media, and the internet now provide platforms and forums for deliberations that to most prognosticators in the 1980's would have been unimaginable. They have dramatically increased the range of design choices for the forums in which deliberations can be conducted: virtual meetings, email, social media, collaboration sites, enterprise intranets, search engines such as Google, blogs, and open sourced innovation to name a few.

**Addressing the New Technological Imperative in the "Digital Coal Mines"**

Algorithms, "big data", and analytics are also critical inputs in the contemporary design of deliberations, especially with the increasing pervasiveness of cognitive computing and machine-driven decision-making. While there have been numerous benefits of these new technologies – for example, increased efficiencies, the automation of dull, dirty, and dangerous jobs, greater consumer convenience, and so on – there is also the potential that we are entering an era of digital Taylorism and facing a new technological imperative; in other words, a 21$^{st}$ century version of the introduction of long wall technology in the British coal mines. We are hearing more and more examples of this digital Taylorism as the progress of digital technologies creates increasingly sophisticated methods for measuring, tracking, and otherwise micro-managing people. For example, Alex Pentland (New York Times BITS Blog, 2014) from MIT has developed a sociometric badge that tracks who employees interact with, their tone of voice, and their propensity to talk or listen. A recent article in the New York Times described how Uber has employed hundreds of data scientists and behavioral scientists to create algorithms that motivate and manipulate their freelance drivers to work longer and harder even in locations and at times that are less lucrative (Scheiber, 2017).

Digital technologies all rely on code, and code is not value-neutral. As Parmar and Freeman (2017) have written: *it* (code) *contains many judgments about who we are, who we should become, and how we should live* (p.17). Analytics and algorithms may operate according to the laws of mathematics, but they are developed by people. They incorporate, almost always implicitly, the values, biases, preferences, and assumptions of the people who design them as well as the dominant worldview of the society in which they live. It is important to discern whether these digital technologies are reinforcing centralized decision-making, hierarchical governance, and an ethos of command and control or promoting self-regulation, lateral coordination, mutual adjustment, and an ethos of collaboration.

Berners-Lee, the inventor of the world-wide web, recognized that *technologists cannot simply leave the social and ethical questions to other people, because the technology directly affects these matters* (Berners-Lee, 2000, p. 124). Parmar and Freeman further recommend that *We need to have better conversations about the role of purpose, ethics, and values in this technological world, rather than simply assuming that these issues have been solved or that they don't exist because "it's just an algorithm." Questions about the judgments implicit in machine-driven decisions are now more important than ever if we are to choose how to live a good life.* (2017, p. 17).

Herein lies some extremely important challenges for this and subsequent generations of organizational design and change theorists. First, how can contemporary organizations, networks, and ecosystems exercise organizational choice and disobey the technological imperative of the "digital coal mines" with positive economic as well as human results (Trist, 1993). In this digital era, how can we truly achieve the joint optimization of both the social and the technical subsystems? And at an even more fundamental level, how can individuals avoid becoming become mere extensions of our digital technologies? How, for example, can we use intelligent technology to augment people's knowledge, insights, skills, and judgment? Pava (1985) warned against inappropriate reliance on technology, saying there was a risk of engendering passivity and dulling individual efforts. Lanier (2013) echoed Pava's warning: *I fear that we are beginning to* *design ourselves to suit digital models of us, and I worry about a leaching of empathy and humanity in that process.*

But Pava not only warned us about the potential consequences of microprocessors and digital technology, he provided us with a robust approach to the sociotechnical design and change of non-routine knowledge work. While he offered an early roadmap for our increasingly turbulent environment, our challenge is to extend and develop Pava's approach in light of the questions (or deliberations) raised above. In so doing, we will be better able to shape our digital tools rather than have them shape us.

**Summary Thoughts**

Pava addressed the challenges of applying STS theory to the design of non-routine work-systems in 1983 with the publication of *Managing New Office Technology: An Organizational Strategy*. The choice of title, and the emphasis on advanced office technology rather than knowledge work, may have limited the recognition of Pava's pivotal contribution to the fields of organizational design and change. As noted above, the "office of the future" was the catch phrase of scholars, consultants, and entrepreneurs of that era (cf. Tapscott, 1982; Baetz, 1985).

We believe that Pava's work is still highly relevant in today's digital era. Purser and Cabana (1998, p. xxi) said of Pava and his vision for the information society and knowledge work:

> *Pava had a laser-like intensity about him. He felt that the future success and growth of knowledge-based organizations depended on managing deliberations – the way people come together to create, share and utilize knowledge. Bureaucratic organizations – built on the premise of fixed formal offices, where authority is based on one's position in a hierarchy – were antithetical to effective knowledge creation and knowledge utilization. Self-managing forms of organization would be needed to tap the creativity and talents of professional knowledge workers.*

Pava was remarkably prescient regarding the potential impact of microprocessors and related technologies on the world of non-routine knowledge work. He recognized that the distinctions between blue-collar and white-collar work were decreasing due to increased reliance on knowledge work in both the office and the factory, especially given the emergence of "smart" equipment and advanced manufacturing. His influence on the theories and practices of STS-D, STS-C, and organizational change would arguably have been much more significant had he not passed away at a very young age. In fact, we believe that the full impact of his contributions to the design of knowledge work systems and contemporary enterprises is yet to be realized.

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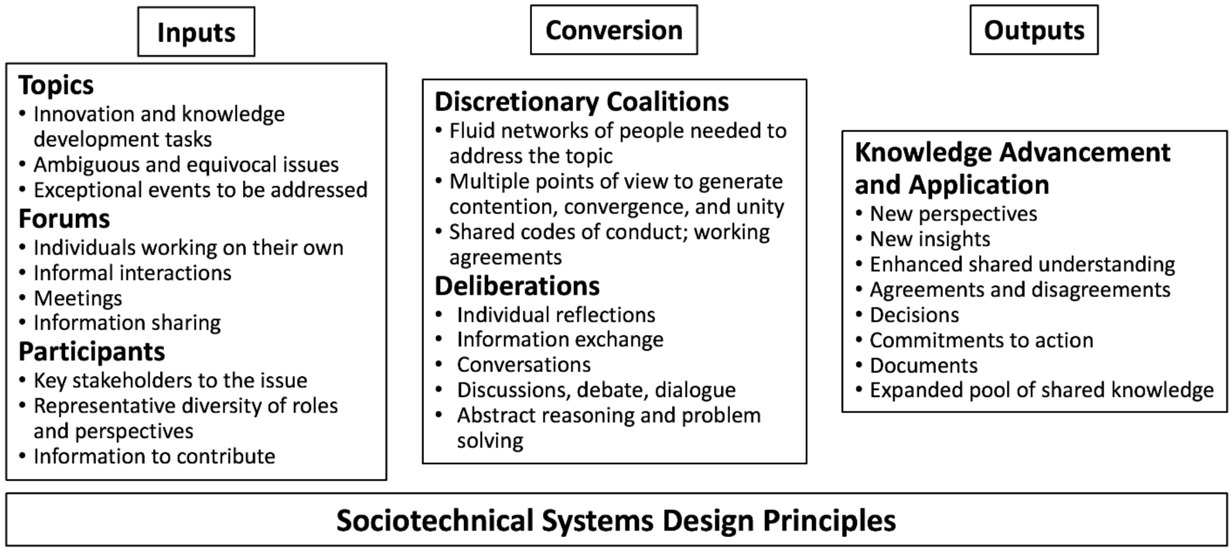
**Table 1. Changing Nature of Work and the Work System**

| | 1950's to 1980's | 1980's to Present |
|---|---|---|
| **Environmental context** | • Stable environment | • Unstable, turbulent environment |
| **Salient characteristics of the technical system and the tasks** | • Routine<br>• Long-link, mechanical processes<br>• Unitary, convergent, linear, sequential conversion process with well-formed problems and programmed series of steps<br>• Largely unvarying tasks with limited variety<br>• Defined<br>• One specified way<br>• Sequential interdependence of subtasks<br>• Repetitive, short cycle tasks | • Increasingly non-routine<br>• Integrated information processes<br>• Multiple concurrent, nonlinear, non-sequential conversion processes with ill-structured problems and un-programmed activities<br>• Highly variable tasks with unclear inputs and outputs and greater variety<br>• Undefined<br>• Many potential ways<br>• Saturated, pooled or team interdependence<br>• Non-repetitive, long cycle tasks |
| **Salient characteristics of the social system** | • Work groups with shared identity | • Professionals with specialized expertise and more individualistic orientation |
| **Salient characteristics of the coordination mechanisms** | • Position-based authority<br>• Clear shared goals<br>• Hierarchical coordination; authority-based | • Expertise-based authority<br>• Multiple, competing goals<br>• Hierarchical and lateral coordination; consensus-based |
| **Variance analysis** | • Obvious<br>• Downstream with clear cause-effect relationships<br>• Recognizable patterns | • Hidden<br>• Multi-determined and multi-directional causal linkages<br>• Largely unpatterned |
| **Typical design options** | • Autonomous work groups<br>• Job enrichment<br>• Multi-skilling | • Discretionary coalitions and role networks<br>• Job simplification to reduce the equivocality of problems<br>• Reticular organization with fluid distribution of information and authority |

**Figure 1. Deliberation Conversion Process**



## Table 2. STS Design of Non-routine Knowledge Work Systems

| Step # | Step | Activities |
|---|---|---|
| 0 | Map the Target System | The purpose of this step is to develop a preliminary map or sketch of what is going on in the unit to be analyzed by tracing the key deliberations in which people are engaged. This is accomplished by interviewing a diverse sample of people in the organization and tracing complex documents as they move through the process. |
| 1 | Entry, Sanction, and Startup | During this step, the STS participative design approach and a design philosophy statement are formally approved and the Design Teams and Steering Committee are established. |
| 2 | Initial Scan | The purpose of an initial scan is to discern the mission or goals of the system and the governance processes and coordination mechanisms that enable or inhibit collaboration in pursuit of the mission. The mission and governance system provide the impetus for a self-regulating system of players who define and iteratively evolve the technical subsystem in terms of the key deliberations or issues they need to address in order to achieve the mission. |
| 3 | Analysis of the Technical System | In this step, the deliberations are listed and the major deliberation topics requiring the most scrutiny are identified. The technical analysis of deliberations involves the identification of the nature of the different forums in which these deliberations occur, the participants and how they either contribute to or use information, and the recurring errors and information gaps in for each major topic. |
| 4 | Analysis of the Social System | The social subsystem is defined in terms of discretionary coalitions that are needed to conduct the deliberations effectively. The role network for each major deliberation is mapped. The values of every participant in the deliberation, the interdependent parties, the divergent values, and the tradeoffs, especially problematic tradeoffs, are identified. The social system design does not try to eliminate differences, but to create a mutual understanding and a common orientation such that trade-offs can be settled on an intelligent and ongoing basis. |
| 5 | Work System Design | Roles and responsibilities and the discretionary coalitions for each of the major deliberations are defined. The Design Team also synthesizes the technical and social analyses and develops a set of organization design recommendations -- structural changes, human resource policies, coordination mechanisms, and enabling technologies -- that support and reward the sort of integrative perspective necessary to the successful functioning of the discretionary coalitions. |
| 6 | Approval and enactment | The Design Team recommendations are reviewed with the Steering Committee and senior management, revised as needed and then “sold” to the rest of the organization and implemented. Beyond noting that additional skill training may be necessary, Pava does not address in any detail the issues that would be considered in many organizational change management models. We can only speculate that this was probably due to the participative nature of the design process and the increased level of acceptance that typically engenders. |

**Table 3. Description of the Four Categories of Knowledge Barriers**

| Category of Knowledge Barrier | Description |
|---|---|
| 1. Lack of a common frame of reference | This knowledge barrier includes cognitive frame-of-reference barriers typically associated with differences in functional expertise, values, cultural norms at both the corporate and national or ethnic levels, and language. This knowledge barrier is most likely to occur when the discretionary coalitions span company, sector, and national and cultural boundaries. One of the most often overlooked yet critical design activities is to establish a common lexicon or shared language. |
| 2. Failure to share knowledge. | Failure to share knowledge occurs when key participants are not included in the deliberation or when the participants in the deliberation are unwilling to cooperate. In highly competitive organizational cultures with "knowledge is power" norms, participants may be reluctant to share what they know. Similarly, when there are conflicts or distrust between groups or among individuals, relevant information is often withheld. This knowledge barrier is often exacerbated when there are unrealistic time frames and other time pressures that serve to narrow a person's focus to his or her immediate task at the expense of sharing knowledge that might benefit other participants in the deliberation. |
| 3. Lack of knowledge | This knowledge barrier is about the actual work, the procedures and processes, or the capabilities that can slow or derail progress regarding the deliberation topic(s). |
| 4. Failure to use knowledge | With this knowledge barrier, the knowledge for completing the task, deliberating, and making decisions exists but is either ignored or used improperly. |

**Figure 2. Updated Deliberation Conversion Process**