Reclaiming Contemporary Information Systems: The Sociotechnical Toolbox

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Abstract

This paper presents a retrospective overview of the Sociotechnical Toolbox (STT), an open framework for Contextual Systems Inquiry explicitly designed to support and aim for professional and organizational excellence. Integrating insights from the Infological Equation and Critical Systems Heuristics, the STT reframes approximately 40 sub-methods into a flexible matrix of non-linear heuristics that expose unreflective practices and safeguard professional autonomy. The framework is grounded operationally in high-frequency, participatory field interviews and observations, using a variety of questionnaires strictly as complementary diagnostic instruments to support the wider analysis. A three-decade record encompassing over 2,400 intensive, qualitative action research engagements across 900 multi-sector organizations validates the transferability of its design principles. We demonstrate how the framework empowers unique local actors to facilitate effective change and structure uncertainty amidst modern transformations like Industry 5.0 and autonomous AI agency. By supporting continuous development toward professional excellence, the STT enforces long-term cognitive, workforce, organizational, and environmental sustainability, enabling human activity systems to secure their own professional sovereignty and maintain localized decision-making authority.

Keywords

Sociotechnical Toolbox, Contextual Systems Inquiry, Double Helix, Structuring Uncertainty, Participatory Design, Functional Stupidity, Organizational Excellence, Work Systems, Industry 5.0, Human-AI Agency.

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1. Introduction and Foundations

This paper reviews the historical trajectory of the Sociotechnical Toolbox (STT), tracing its evolution into contemporary socio-technical practice [9]. The STT draws upon a dual-helix, multi-perspective framework to move socio-technical scholarship and practice beyond passive, harmony-seeking approaches. Instead, it introduces a critical-interpretive lens. This lens supports human agency, professional autonomy, and systemic resilience against the unequal power dynamics of automated environments. Through this perspective, organizational failure is not seen as a simple technical defect. It is a direct result of contextual blindness within complex human activity systems [69]. Maturana and Varela [40, 41] view this misalignment as a failure of structural coupling, where rigid systems disconnect from fluid organizational

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realities. Structural coupling reminds us that an information system does not mechanically inject data into an environment; rather, the system and the human workspace must co-evolve so that changes in one trigger a natural, adaptive change in the other. Cybernetically, this mismatch reflects Beer's [22, 66] warnings on viability: organizations collapse when static structures fail to absorb environmental complexity. Bateson [5] also reminds us that cognition is spread across entire relational networks, encompassing human actors, actions, and contexts, rather than locked inside isolated artifacts. Because organizations are messy, human-intensive spaces driven by different purposes, we cannot treat them as predictable machines [25, 28, 64]. Addressing this complexity requires what Vickers [58] called an appreciative system. In an appreciative system, human actors do not just pursue algorithmic goals. They continuously negotiate and regulate relationship norms through lived experience. An appreciative system is therefore not an algorithm to be optimized, but an ongoing human capability to judge what is both situationally real and organizationally valuable.

1.1. Deconstructing the Mechanistic Paradigm

For decades, dominant management traditions have relied on a mechanistic delusion. This perspective mistakenly reduces organizational change to a closed engineering exercise, promising a straight line from an idealized State A to a predetermined State B. This trap forces practitioners into what Nissen [47, 80] called a 'methodological quagmire.' Here, standardized models systematically strip away vital political, cultural, and human dimensions [42, 53].

By treating meaningful social practices as value-neutral mechanics, modern paradigms fail when addressing human crises [21]. Challenging this rationalistic bias, Ciborra [30] shows how systems inevitably "*drift*" from their original design when they collide with everyday human practices. "*Stuff happens*," as Markus and Robey [38] observed. This means that management cannot simply enforce a new tool and expect predictable results; technology and human habits adapt to each other in unpredictable loops. Technological outcomes emerge non-linearly from complex, erratic interactions rather than being determined solely by tools or users.

To navigate this, complex problem-solving must acknowledge that technical systems cannot be separated from the evolving social and communicative contexts of human actors [25, 26, 28, 48, 55, 56, 59, 65]. This requires clear phenomenological and hermeneutic methods that fit the actual experiences of end-users [81].

1.2. Emancipation and the Fallacy of Algorithmic Neutrality

This socio-technical stance requires rejecting rigid systems control. Instead, we must favor emancipatory frameworks that expose power imbalances and foster open stakeholder communication [34, 43, 45, 46, 82]. Successful organizational change depends on integrating technical design directly with the shifting dynamics of the social subsystem [50].

When rigid, preset workflows over-engineer infrastructure, they violate Cherns' [29] principle of minimal critical specification. This top-down imposition stifles local adaptability and guarantees operational failure. This means design should intentionally leave workflows unfinished at the top level, leaving the final details to be filled in by the workers who actually face the daily operational realities [29]. Enforcing top-down mandates in a socio-cultural vacuum creates an artificial overlay. When formal systems ignore organizational hospitality, the intended infrastructures become a hostile, alien presence [30]. Consequently, imposing an

objective, "*neutral*" design paradoxically spreads misinformation. It does this by suppressing the local context needed to interpret data accurately [14, 15, 16]. This failure is clear in healthcare when clinical machine learning models fail. They rely on sanitized data and abstract "*ground truths*" while ignoring the non-linear realities of daily practice [23]. Attempting to replace situated judgment with objective neutrality erases the unique realities of human actors, producing discriminatory and harmful outcomes [24]. Dolata et al. [31] similarly dismantle this illusion. They prove that algorithmic fairness is a situated property. It emerges entirely from the interplay between individual sense-making and organizational context, rather than from isolated mathematical adjustments. To bridge the gap between these foundational critiques and daily practice, this paper moves from our deep theoretical infrastructure (Section 2) and historical evolution (Section 3) straight into an explicit overview of the STT's 40 sub-methods (Section 4). By anchoring this extensive philosophy within three decades of field-tested experience (Section 5), we demonstrate that these concepts are not abstract models, but active tools for facilitating effective change toward organizational and professional excellence.

2. Theoretical Foundations of Contextual Inquiry

2.1. Value-Reflexive Thinking and Contextual Use

Contemporary security practices show this operational friction. When critical executive roles like the CISO rely strictly on a rigid compliance science rather than the contextual art of human negotiation, they trigger widespread operational resistance [51]. This complex interplay is visible in artificial intelligence deployment [1]. It proves that digital adoption is never a simple technology substitution. Instead, it is an emergent process constantly disrupted by friction between technical subsystems and legacy organizational routines. The Sociotechnical Toolbox (STT) navigates this intersection by drawing directly on the systems tradition [7, 8]. This tradition establishes that usefulness cannot exist independently of continuous, reflective human use. Critical systems thinking acts as an indispensable tool to fix structural blindness [17]. To counter dominant change management approaches, practitioners must embrace contrarian [7, 61], value-reflexive thinking. This is necessary to challenge status-quo assumptions and expose unexamined technical rationalism. This shift is necessary [36]. Standard organizational frameworks reduce systemic value to corporate outcomes. This completely obscures how technology is actually interpreted, reshaped, and realized through localized individual use. In short, a system's true value is not determined by its technical specifications when it is built, but by how it is continually interpreted and reshaped through daily human use [7, 8]

2.2. Practical Wisdom, Workarounds, and Organizational Sensemaking

By embedding human values into technical architectures from the outset, change management can prevent digital ecosystems from becoming alien, failing presences [52]. This reorientation addresses Walsham's [56] call to look beyond narrow operational utility. It questions whether technological deployments contribute to a human-centric world. This imperative is heavily reinforced by contemporary socio-technical scholarship. Here, recent work-system frameworks emphasize that the aggressive digitalization of enterprise talent and workforce configurations lacks systemic effectiveness if divorced from a contextual, interpretative approach [86]. Grounded in a practice-based view, ethical action within complex environments cannot rely on

rule-bound compliance matrices. It depends on practical wisdom (phronesis), which is a capacity developed through lived human experience [32, 61]. Ignoring these human dynamics triggers organizational self-sabotage. When structural constraints marginalize employee identities, workers must construct informal bypasses and workarounds to achieve primary operational targets [13, 18, 20].

This reliance on unofficial detours exposes a critical failure to establish "*local design shops*." These are collaborative spaces where future users maintain control over system development as both problem owners and problem solvers [18, 33]. Rather than indicating malice, defensive workarounds act as a protective reaction to evade operational threats or professional embarrassment [40, 41]. When a system makes it impossible for people to do their jobs safely, circumventing the rules becomes a necessary act of professional survival. The true self-sabotage occurs when management aggressively tries to suppress these workarounds; this enforcement forces adjustments underground, strips the organization of operational visibility, and locks the underlying errors permanently in place [2, 61].

This dynamic exemplifies bricolage, where workers tinker and improvise with local resources to overcome rigid technological failures [30, 50]. Ultimately, this continuous improvisation underscores foundational premises of organizational sensemaking. Human actors do not execute pre-programmed technical instructions. Instead, they actively and retrospectively construct meaning within ambiguous contexts to maintain operational coherence [14, 57].

2.3. Languaging, Methodolatry, and the Rejection of the Cookbook

Rather than pursuing illusory "*problem solving*," a critical socio-technical perspective shifts focus toward contextual inquiry and systemic dialogue [14]. This view treats information systems as evolving, human-centered practices rather than static tools. Cultivating such a perspective demands a commitment to value-reflexivity [7, 61]. Managing this complexity requires continuous, structured learning cycles rather than permanent, static technical fixes [7, 27].

Organizations actively *'bring forth'* their operational realities through everyday languaging [40, 41, 60]. To break free from traditional functionalist traps, this perspective explicitly rejects a rushed push toward premature consensus or immediate *'problem solving'*. Such a rush artificially flattens workplace ambiguity. Instead, in alignment with the foundational tenets of Strategic Systemic Thinking, the framework shifts the analytical objective toward the divergent '*complexification*' of problem resolving [90]. This ongoing production of sensemaking environments illustrates how reality functions as an ongoing social construct [57].

To overcome the limitations of naive, reductive paradigms, the Sociotechnical Toolbox (STT) explicitly avoids prescriptive approaches. It rejects conceptualization as a step-by-step methodology, a cookbook, or a project management checklist. Instead, the STT functions as an open-ended matrix of non-linear heuristics for Contextual Systems Inquiry (CSI) [7, 9, 14, 80]. The framework integrates the idea that systemic use and individual user reflection form an inseparable, continuous spiral [15].

This rejection of rigid structures aligns with Ciborra's [30] critique of "*methodolatry*." Formal, standardized methodologies fail because they ignore the essential role of human improvisation. They overlook the situational tinkering required to keep real-world systems functional. To break free from this trap, the STT abandons simple machine metaphors. It

conceptualizes organizations through multiple competing and complementary perspectives [42]. By prioritizing non-linear heuristics, the STT actively navigates out of Nissen's [47, 80] "*methodological quagmire.*" Traditional research paradigms distort our understanding of complex problems in that quagmire by systematically stripping away vital human context [48].

2.4. Cybernetic Viability and Design-as-Incomplete

By prioritising continuous, reflective social practice over rigid technical abstraction, the STT systematically rejects the illusion of value-neutral analysis and descriptions of reality [53, 77]. Through its emphasis on localized meaning-making, it functions as an applied phenomenological design practice [59, 81]. This aligns with interpretive traditions that elevate human context over metrics [14, 55]. It recognises that living, cognitive systems navigate environments through self-referential loops [40, 41, 85].

To support systemic navigation, the STT treats the organization as a cybernetic entity. It manages information variety. This echoes Beer's core assertion that an enterprise can only maintain viability if its structural design allows it to dynamically adapt to shifting realities [22]. Systems development thus becomes an active intervention (in other peoples worlds) within Bateson's "*ecology of mind*" [5]. This mapping honours the delicate, interlocking feedback loops connecting human meaning with environmental context [18]. It does this by enforcing a multiperspective stance. This orientation aligns with Zimmer et al.'s assertion that meaningful digital transformation requires actively exposing the hidden assumptions embedded within standard IT development [61].

Neglecting social and organizational contexts triggers expensive technical failures [6, 14]. To prevent this, socio-technical design must abandon rigid, technocentric dogmas in favor of highly flexible, human-centered practices [43, 45, 46, 48]. The STT addresses this gap. It responds directly to Pasmore et al.'s challenge to revitalize socio-technical design frameworks [50]. It transforms classic principles into dynamic, agile heuristics capable of navigating complex, unpredictable digital landscapes.

Furthermore, the framework advances this participatory approach by using Friis' premise [33]. This premise states that ownership and control over systems inquiry must remain exclusively with local actors navigating their own work environments. The STT embraces this ethos by operationalising Cherns' principle of design-as-incomplete [29]. It deliberately treats models as open-ended frameworks that require continuous local completion by their human actors.

2.5. Organizational Hospitality and the Paradox of Neutrality

The STT approach integrates Checkland's view that systems methodologies should function as flexible frameworks [27]. They must facilitate continuous, structured learning rather than rigid methods. By prioritizing a learning cycle, the STT addresses Markus and Robey's call to explore unintended consequences of technology use [38]. It offers an analytical space capable of capturing emergent organizational phenomena before they manifest as systemic failures. The framework is rooted in critical systems thinking and participatory design. It systematically rejects artificial simplification. It also avoids a "*problem-solving*" reductionism [25] that plucks these dynamics out of their lived environments.

Instead, the framework embraces complexity [18]. It injects contextual ambiguity back into information systems development (ISD) through a multiperspective analysis of Human Activity Systems. This openness puts Ciborra's notion of "*hospitality*" into practice [30]. The unpredictable, messy nuances of human contexts are no longer viewed as noise to be eliminated. Instead, they are treated as guests to be hosted and deeply understood. Hosting these nuances is not about making users feel comfortable; it is about recognizing that a system cannot function unless its architecture actively accommodates the messy reality of human friction [30].

Avoiding the paradoxes of neutrality requires resisting the urge to sanitize these environments. Attempts to construct purely objective descriptions accidentally institutionalize misinformation. This happens because rigid structures systematically suppress local, subjective context [14, 15, 16].

The framework mandates that explicit, formalised knowledge of workflows must not override the implicit, unvoiced, and subjective realities of individual human actors who inhabit work systems [7, 18]. These unique professional identities, personal perspectives, motivations, and attitudes continuously recreate the organization. As D'souza and Introna argue, implicit dimensions represent the bedrock of practical wisdom (phronesis) [32]. This embodied ethical intuition is completely destroyed when organizations attempt to force human action into narrow, algorithmic scripts. Ciborra demonstrates that information systems are fundamentally shaped by the inner "*moods*," affections, and everyday lived experiences of the participants [30]. This underlines Maturana and Varela's premise that organisms do not merely inhabit a pre-existing space [40, 41]. Instead, they actively bring forth their own world of experience.

2.6. Pluralistic Realities, Sensemaking, and Emancipatory Inquiry

This process maps directly onto organizational behavior through Weick's [57] theory of sensemaking. Here, actors continuously reconstruct organizational realities through their local identity and a retrospective filtering of cues. This focus on individual subjectivity reflects the emphasis by Checkland and Scholes [26] on surfacing different worldviews. Doing so is a clear prerequisite for systemic change [71].

Consequently, the STT frames this process as an exercise in value appreciation. It integrates the premise from Vickers [58] that human systems must prioritize the continuous, interpretive monitoring of relationships over the pursuit of permanent, static technical fixes. In systemic terms, the fundamental premise is that everything said is always said by a unique observer [40, 41].

An organization is a collection of distinct interpretations of co-existing realities. It is not a single, monolithic representation of objective truth. The STT explicitly promotes this plurality. It recognizes that an organizational universe is a multi-layered social construction. This construction is maintained through the subjective knowledge and shared meanings of everyday actors [95].

Confronting and hosting conflicting perspectives systematically dismantles organizational defenses [2, 61]. This process transforms defensive cover-ups into actionable, double-loop learning opportunities. Such a capacity for ongoing renegotiation aligns with the assertion by Pasmore et al. [50] that contemporary socio-technical interventions must move beyond rigid methods. Instead, they must foster distributed agility and continuous evolutionary capability across all enterprise levels.

By embedding these worldviews into its processes, the STT integrates critical systemic thinking as an active and pragmatic practice. It ensures that work and information systems development remain ethically grounded in the unique context of the local problem owner [14, 17]. Ultimately, this grounding matches neohumanist ideals championed by Hirschheim and Klein [34]. True system success requires an explicit shift toward emancipatory principles that actively validate human interests over oppressive technical rationalism.

Navigating the challenge from Becker [21] to reorient computing paradigms, the framework rejects technocentric illusions. It directly confronts the ethical dimensions of socio-technical survival. Systemic robustness is modeled not as a static metric, but as a situated outcome. This outcome is co-created by the discretionary, interpretive practices of individual users.

The STT integrates this requirement by acting as an interpretive vehicle for value-sensitive design. This ensures that digital ecosystems align systematically with human moral values [52]. By grounding its application in local, human-centered truths, the STT advances the agenda of Walsham [56]. It transforms systems design into a reflective practice explicitly geared toward ethical accountability and human well-being.

To achieve this, the STT balances a naively rigid "*science*" of formal organizing with the interpretive "*art*" required to navigate complex organizational responsibilities and roles [51]. By elevating pluralistic worldviews, the STT actively resists the trajectory identified by Cecez-Kecmanovic [24]. This work warns that delegating complex social processes to automated architectures fundamentally misrepresents human reality in the image of an algorithm.

2.7. Epistemological Purity, the Infological Equation, and the Multiverse

The STT method synthesis does not imply an uncritical blending of multiple objectivist and interpretivist worldviews. It also does not advocate for paradigm hopping. Rather than adopting the complete, conflicting ontologies of its constituent theories, the STT pragmatically draws upon specific insights and conceptual tools from these traditions. It integrates them into a coherent, overarching interpretive perspective. The STT explicitly rejects multi-paradigm complementarism that treats paradigms as casually interchangeable toolkits.

Under this pragmatic interpretive lens, human-realm systems are modeled not as objective entities to be engineered. Instead, they are subjective, epistemological constructs used by local actors to make sense of a complex reality [24, 25, 28, 30, 53]. Attempting to map and manage human systems using abstract models is an illusion that fundamentally misunderstands the messy nature of organizational life [84]. This rejection aligns with the epistemology of Maturana and Varela [40, 41]. They confirm that our cognitive structures do not mirror an outside world. Instead, they generate experience from within our own structural limits.

The STT also integrates the epistemological insights of Börje Langefors' Infological Equation [37]. This models meaning-making and information not as inherent properties of data, but as unique cognitive functions of an individual's pre-knowledge and internalized experience. Ciborra [30] similarly deconstructs the myth of raw data. Data is simply a collection of symbols on a screen; it only becomes meaningful information when a human being looks at it through the lens of their own experience. Thus, information systems and organizational development are emergent consequences of localized individual and organizational learning processes [14, 76].

This situated engagement requires continuous double-loop learning. This is a deeply reflexive process where human actors actively question the internalized values, biases, and

historical pre-knowledge that shape their own cognitive boundaries [7, 8, 15, 16, 18]. Neglecting complex human and ethical factors in systemic problem-solving results in flawed organizational decisions [44].

To ensure this subjective inquiry is not compromised by organizational hierarchies, the STT integrates Werner Ulrich's Critical Systems Heuristics [54]. This perspective promotes boundary critique. It enables actors to expose normativities, challenge power dynamics, and clarify whose values are served by the technical infrastructure [82]. This critical boundary critique is supported through a systemic conversation [7, 8, 9, 16]. It promotes a space where individual double-loop reflections can be externalized and collectively explored. This potentially prevents the dialogue from being hijacked by dominant organizational dogmas.

By accommodating different perspectives, the STT bridges the gap between Langeforsian individual cognition and Ulrichian boundary critique. It integrates a vision of a systemically structured, democratic, professionally oriented [72, 78], and politically aware human dialogue (e.g., [26, 43, 45, 46, 54]). Ultimately, this dialogue becomes an ethical necessity when we accept that there is no single "*universe*" of objective truth. Instead, there is a "*multiverse*" of co-existing, equally valid understandings of realities brought forth by different human observers [40, 41]. Without this dialogue, organizational excellence and sustainable competitive advantage are by definition unattainable.

3. Historical Roots and Methodological Pluralism

While early instructional layouts of the STT superficially mirrored the sequential steps of Enid Mumford's phased ETHICS framework [43, 45, 46] to anchor beginners, this appearance masks a recursive systemic reality. The STT explicitly rejects these traditional phased constraints in favor of emergent, contextual inquiry. It recognizes that engaging with complexity is inherently circular [14, 17, 40, 41]. Typically, instructional sequencing exposes a classic trap of confusing a recipe with the lived capacity to cook. Rules offer initial boundaries, but authentic *languaging* requires actors to transcend static limits for context-dependent practice [60]. This dynamic mirrors the evolutionary trajectory of classic contingency frameworks like Multiview; its original 1985 formulation was deeply promising and inspiring precisely because its open, non-explicit descriptions left space for practitioner improvisation [89]. However, as later iterations grew increasingly prescriptive, explicit, and structurally rigid, they sacrificed this generative flexibility. The STT avoids this evolutionary trap by ensuring that its sub-methods act as a flexible conversational infrastructure, serving to stimulate practitioner reflection rather than dictating a rigid prescription for the inquiry

Rigid, sequential planning creates a false sense of control that blinds management to organic, spontaneous changes [30]; because the STT treats human activity systems as autonomous, self-referential unities, it recognizes that their internal transformations inherently defy top-down external mandates. Successful work-system development requires abandoning hierarchical control for localized situational tinkering [30].

Consequently, the STT transcends the limitations of a prescriptive method to become a dynamic toolbox for continuous systemic conversation and change. This shift reframes purposeful development as an open-ended cycle of individual and organizational double-

loop learning [79], directly expanding the actors' collective capacity to critically reflect upon, structure, and optimize their own evolving realities.

This evolutionary trajectory revealed critical socio-technical design principles regarding methodological scaffolding and practitioner behavior. Initially, the STT functioned as a simplistic framework delivering generic advice. It operated under the assumption that professional analysts possessed native familiarity and a deep interpretive understanding of analytical tools. Fieldwork quickly dismantled this premise, exposing severe limitations in both execution and conceptual maturity among practitioners [79]. Over three decades, it became evident that dimensions professionals assumed to be implicitly obvious were, in practice, systematically forgotten or omitted during rapid deployments.

To counteract this operational amnesia, the toolbox progressively incorporated granular hints and explicit structural prompts [83]. This mirrors Hans-Erik Nissen's foundational formulation of the double-helix relationship [94], which establishes the indivisibility of system design and human use, framing systemic inquiry as an ongoing conversational intervention.

A prominent example of this co-evolutionary design is visible in the framework's handling of security boundaries. Cybersecurity was initially treated as an implied, foundational baseline. However, practitioners consistently failed to account for it proactively, which resulted in expensive, retrospective, and ultimately unsatisfactory fixes. Because of this, the framework transitioned from providing isolated security advice to embedding explicit cyber-physical security matrices natively across all 40 sub-methods, regardless of the inquiry's core focus. The sequence and configuration of the toolbox remain entirely emergent. This empowers local actors to leverage their situated intimacy to navigate the unpredictable realities of their specific organizational landscape [7, 14, 16].

3.1. Adapting Soft Systems Principles to a Critically Informed Stance

The STT does not apply Soft Systems Methodology (SSM) as a method. Instead, the framework draws upon specific soft systems tools, such as Rich Pictures, CATWOE, and conceptual modeling. It dismantles and reconstructs their application to transform them into active instruments for critical, emancipatory boundary critique. The STT demonstrates how practitioners can dismantle and reconstruct existing tools and their application to navigate complex organizational environments.

Grounding the framework in a critical stance echoes Ciborra's rejection of romanticized corporate teamwork [30]. This perspective reframes organizational arenas as complex political landscapes fractured by strategic maneuvering, hidden power dynamics, and deep-seated conflicts [18]. Rather than succumbing to superficial, consensus-seeking exercises that protect entrenched hierarchies by harmonizing worldviews, critical socio-technical inquiry must explore dominant voices to foster professional and organizational excellence.

Forced strategic alignment functions as an autopoietic defense mechanism and a top-down control overlay. This overlay neutralizes dissenting voices to conserve executive power relations [40, 41, 74]. When power preservation supersedes authentic organizational learning, this manufactured consensus chokes professional competence [30, 44]. This directly triggers flawed corporate decisions and systemic technical failure.

To prevent this distortion, the STT synthesizes soft systems tools with Werner Ulrich's Critical Systems Heuristics [54] and Börje Langefors' [37] Infological Equation. This critical integration allows the interpretive STT to expose individual cognitive boundaries and structural asymmetries simultaneously [75]. This adaptation reorients traditional soft methodologies, shifting them from simple interpretive discussion aids into targeted mechanisms designed to map structural inequalities.

- **Dismantling False Consensus:** Rejecting the illusion that stakeholder accommodation is naturally achievable in autocratic or bureaucratic workspaces, the framework leverages its Change-Potential and Organizational Boundaries exploration spaces to actively surface systemic friction and unvoiced dissent.
- **The Critical Evaluation of Pre-Knowledge:** While traditional soft methods accept worldviews as static baselines, the STT applies Börje Langefors' infological equation [37], (I = i(D, S, t)), to deconstruct how information (I) emerges from data (D) interpreted through individual pre-knowledge (S) over time (t). This evaluates how corporate structures restrict or manipulate this historical capacity to learn.
- **Activating the Normative Critique:** By weaving Werner Ulrich's twelve boundary questions of Critical Systems Heuristics (CSH) [54] directly into its mapping tools, the STT forces a shift from passive description to active critique across four dimensions (Motivation, Control, Knowledge, and Legitimacy). This structurally prompts workers mapping technical data streams to pivot from how the system is to how it ought to be configured.
- **Internal Heuristics and the Mirror of Flux:** Consequently, the framework serves as an adaptive mirror for contextual inquiry. It dynamically evolves alongside the fluid configurations of living human activity systems [7, 11, 14].

3.2. Two Pragmatic and Philosophical Avenues of Application

Preserving the philosophical integrity of Contextual Systems Inquiry (CSI) requires dismantling the assumption that the Sociotechnical Toolbox (STT) operates on cross-paradigm complementarism. While drawing upon a multitude of reinterpreted tools and methods [25, 26, 27, 28, 35, 39, 43, 45, 46, 54, 67], this methodological pluralism does not constitute an epistemological compromise. The nature of an inquiry is dictated entirely by the *user's personal guiding philosophy* rather than tool provenance, ensuring the overarching posture remains inherently interpretive, systemic, and critically informed [7, 15, 16, 17, 18, 53, 83].

The Simplistic, Uncritical Application (Surface Mapping): When a project team bypasses the critical stance, the sub-methods function as a literal, unmediated mapping toolkit.

- **Baseline Pragmatic Utility:** Elevates frontline employee voice, offering an immediate operational alternative to rigid, top-down corporate checklists [83].
- **Pedagogical Scaffolding:** Guides novices into a richer language-game, preventing premature reductionism by allowing localized context to inform final technical configurations [60, 77].

The Inherent Interpretative and Critical Inquiry (Authentic Alignment): This avenue aligns directly with the core philosophy of CSI, deploying the toolbox as a unified, critically informed framework.

- **Cognitive Subordination:** Technical abstractions are subordinated to Langefors' Infological Equation [37], establishing that data remains meaningless until interpreted through subjective pre-knowledge over time.
- **Collaborative Languaging:** This individual meaning-emergence is operationalized collectively through shared language-games [60], transforming basic task analysis into a sharp Ulrichian boundary critique [54] that uncovers whose values the system serves.

By defining information as an emergent human property, the STT maintains a consistent, critically informed posture. It explicitly treats work systems as politically contested professional spaces. Ultimately, the STT allows the professional workforce to assert their professional authority, enabling them to continuously and democratically co-design their own social and technical futures.

4. The Categories of Exploration Spaces

To operationalise Contextual Systems Inquiry (CSI), the STT structures its 40 sub-methods into eight distinct exploration spaces. Supported by visual modeling templates and specialized questionnaires, this taxonomy provides structural guidance for participatory interviews and systemic dialogue [7, 9, 14, 16, 80] without imposing a linear execution path.

This multi-perspective inquiry prioritizes the lived experiences of individual employees by providing structured guidance, dedicated visual modeling templates, and specialized questionnaires to facilitate participatory interviews and systemic dialogue. The outline of the eight exploration spaces, which sequentially details the 40 sub-methods, is structured as follows:

4.1.1. Exploration Space a), Contextual and Structural Base Space

Investigating the context of the human activity system, this space evaluates organizational learning boundaries, structural complexity, and transformation baselines. It is supported by the Enterprise, Activity, and Organizational Learning Questionnaires.

1. **Change Dynamics (Why Change):** Unpacks the core drivers and underlying symptoms of systemic discomfort behind the proposed transformation.
2. **System Sustainability:** Evaluates long-term operational viability and resilience under review.
3. **Activity Metrics:** Examines the actual behavioral patterns and hidden, informal routines of organizational actors.
4. **System Boundaries:** Maps the dynamic boundaries and structural tensions between the localized work system, its underlying subsystems, and the broader organizational supersystem.
5. **Holistic Multi-Criteria Benefits:** Explores conflicting definitions of what constitutes a "successful" system outcome among diverse actors.

6. **FACTOR Criteria Matrix:** Deploys a targeted multi-perspective grid to expose critical structural dependencies.
7. **Knowledge Management:** Maps how organizational intelligence is generated, shared, or bottlenecked within informal networks.
8. **Interaction Vectors:** Dissects the communicative dialogues and technical paths between human actors and their immediate work environments.
9. **Organizational Learning:** Assesses the collective capacity of the workforce to reflect upon experience and alter operational habits.
10. **System Evolution (Existing vs. Future):** Contrasts current operations with potential configurations to support organizational self-design.
11. **Logical Architecture (Input-Output):** Breaks down information flows using structural models reframed as interpretive vehicles.
12. **Complexity & Vertical Hierarchies:** Locates where top-down corporate silos constrain organizational knowledge flows.
13. **Contextual Landscape:** Evaluates the local history and operational context of the work system, tracing how the historical execution of processes iterates and conditions changes.

4.1.2. Exploration Space b), Task and Information Coordination Space

Reframing methodology traditions, including SSM, ETHICS, and Object-Oriented analysis, through an interpretive lens, this space aligns strategic intent with practical task realities using the Interaction Questionnaire.

14. **Objectives Definition:** Unpacks the explicit strategic targets and organizational intentions under review.
15. **Task Mapping:** Details the situated operational activities required to achieve those broader strategic aims.
16. **Information Needs:** Investigates the specific analytical requirements human actors need to perform their duties effectively.
17. **Coordination Matrix:** Maps the cross-functional relationships among objectives, tasks, and information to expose gaps where technical structures fail to support meaningful contextual use.
18. **Decision Support Systems:** Critically evaluates whether organizational processes and emergent architectures (including AI) enhance or constrain informed professional judgment.

4.1.3. Exploration Space c), Psychosocial Alignment and Security Contract Space

This category integrates participatory design tenets with modern behavioral security analysis, investigating the alignment between worker satisfaction, systemic variances, and security practices. It is supported by the Socio-Technical Questionnaire, the Sustainability Questionnaire, and the Information and Cyber-Security Questionnaire.

19. **Diagnosis of Efficiency Needs:** Evaluates the technical capabilities and resource requirements within the human activity system.

20. **Key Variance Matrix:** Isolates and maps the unpredictable anomalies, operational errors, and disruptions that emerge within situated activities.
21. **Variance Management:** Tracks how closely correction loops are managed by frontline actors versus top-down corporate oversight.
22. **IS and Cyber Security Management:** Evaluates the formal governance structures and compliance frameworks surrounding the system.
23. **IS and Cyber Security Overview:** Explores how technical security policies function as disruptive "overlays" that prompt employees into defensive workarounds and accidental self-sabotage.
24. **Information Security, Warfare and Management:** Critically evaluates how security, warfare, and management processes either support a professional's privacy, data autonomy, and informed judgment, or sabotage them through asymmetric corporate surveillance, systemic exploitation, and un-trusted data environments.
25. **Diagnosis of Job Satisfaction Needs:** Facilitates deep interpretive inquiry into the psychological fulfillment, well-being, and morale of professional actors.
26. **Knowledge & Psychological Contract:** Deconstructs the unwritten expectations between employees and management regarding skills preservation and professional growth.
27. **Support / Control & Task Contract:** Exposes the systemic structural tension between corporate monitoring mechanisms and localized operational autonomy.
28. **Conclusion and Overview of Job Satisfaction Needs:** Integrates individual motivational requirements to preserve human agency and professional identity within technical designs.

4.1.4. Exploration Space d), Anticipatory Horizon Mapping Space

Moving beyond static, near-term operational milestones, this space uses the Sustainability Questionnaire to support an expansive, anticipatory dialogue among local actors. This inquiry functions as an active platform for systemic reflection, synthesizing historical organizational learning with present baseline knowledge to map out unexamined future potential paths.

29. **Future Analysis:** Replaces linear forecasting with collaborative workshops, empowering stakeholders to contrast known structural constraints against flexible future choices to evaluate how proposed configurations withstand environmental volatility.

4.1.5. Exploration Space e), Socio-Technical Goal Optimization Space

Rather than pursuing narrow, engineering-driven metrics, this space serves as a participatory arena where the collective workforce actively deliberates upon and negotiates conflicting organizational and professional parameters.

30. **Socio-Technical Parameter Specification:** Empowers stakeholders to co-design and place technical performance requirements directly side-by-side with localized human well-being criteria.

31. **Resolution of Systemic Contradictions:** Facilitates deep collective dialogue to challenge and reconfigure environments where automated performance metrics threaten to degrade job quality.
32. **Joint Design Harmonization:** Formulates a shared, dual-axis operational model, ensuring any future technical infrastructure is structurally subordinated to expand human capability, learning, and workplace agency.

4.1.6. Exploration Space f), Alternative Structural Configurations Space

This space serves as a collaborative sandbox designed to disrupt path-dependencies and historical dogmas, challenging stakeholders to collectively generate, critique, and explore unexamined organizational and technical futures.

33. **Socio-Organizational Architectures:** Empowers teams to deliberately configure flexible administrative frameworks, self-managed team models, and decentralized work structures that expand localized professional sovereignty.
34. **Interpretive Technology Frameworks:** Guides the collective design of alternative technical architectures and human-AI collaborative interfaces, explicitly treating technical infrastructures as open systems meant to support, rather than automate, situated human practices.

4.1.7. Exploration Space g), Participatory Action and Transition Space

Rooted in the political and democratic tenets of Scandinavian Participatory Design, this space ensures local actors remain the supreme authors of their own change processes, utilizing the Change-Potential Questionnaire as an active debate catalyst.

35. **Collective Action Pathways** (Achieving Objectives): Formulates the democratic agreements and shared operational pathways necessary to actively manifest the co-designed work system.
36. **Socio-Political Friction Mapping** (Implementation Diagnosis): Empowers the workforce to collectively identify and dismantle structural hierarchies, institutional inertia, or asymmetric power barriers that threaten the transition.
37. **Autonomy Evaluation Criteria** (Benefit Management Objectives): Establishes qualitative benchmarks driven by the workers themselves to continually audit whether the new architecture protects professional sovereignty and agency.
38. **Evolutionary System Realization** (Benefit Management Plan): Replaces static corporate roadmaps with a flexible, worker-governed scaffold to guide long-term, organic adaptation as localized needs change.

4.1.8. Exploration Space h), Ongoing Evaluation and Radical Self-Reflexive Space

This final space explicitly rejects artificial project completion dates, establishing the toolbox as a permanent evolving support tool for collective systemic mindfulness and continuous contextual critique.

39. **Double-Loop Reflexive Audit** (Evaluation & Self-Reflective Element): Prompts both the embedded facilitator and the organizational actors to critically cross-examine their own shifting biases, power configurations, and emerging worldviews.
40. **Systemic Impact Tracking** (Project Evaluation): Investigates the non-linear trajectories, hidden vulnerabilities, and unintended socio-technical consequences triggered across the wider enterprise.
41. **Hermeneutic Mirror and Synthesis** (Case Summary and Overview): Aggregates and develops the contextual knowledge generated during the inquiry, re-introducing these insights back into the workspace to support a subsequent, deeper learning spiral.

4.2. Dynamic Interdependence and Fluidity of Sub-Methods

The sub-methods do not function as isolated analytical steps; they form an interdependent, cybernetic network where the application of a single heuristic alters the variable parameters of the others. As local actors explore and share insight within one space, the assumptions of previously explored spaces are changed, compelling the team to recursively re-examine their system boundaries at a higher degree of granularity.

The application of any single heuristic inevitably reverberates across the entire inquiry space, whether exploring localized task coordination or mapping systemic boundary changes. These localized interventions both prompt and alter the understanding and application of subsequent repetitions. The involved facilitators and local actors are supported to reconfigure the application of tools in infinite combinations. Which is providing a direct response to the messy, unfolding realities of the human activity system under review. Several key systemic challenges illustrate how these independent sub-methods dynamically interrelate and recur across the entire toolbox:

- **Cyber-Physical Security Convergence** (pervasive): Instead of isolating information technology from physical workflows, the heuristics map vulnerabilities as emergent phenomena born at the messy intersection of formal governance policies, spatial design, and localized employee adaptations.
- **Multi-Dimensional Sustainability Vectors:** Rather than treating sustainability as a static corporate constraint, the toolbox embeds it as an active design benchmark across all spaces, guiding the workforce to continuously audit whether emergent technical configurations nourish or deplete collective learning capacity, cognitive bandwidth, and organizational resilience.
- **Recursive Boundary Critique:** Rejecting static, up-front project scopes, the architecture positions boundary definition as a fluid variable; as localized pre-knowledge is articulated, the perceived divisions between internal team routines, algorithmic architectures, and macro-environmental realities shift, requiring teams to iteratively rewrite early descriptive models.

Because the sub-methods are simultaneously autonomous, structurally intertwined, and inherently repeatable, they do not trap the analyst in a rigid analytical silo. This allows the inquiry to remain as fluid, iterative, and complex as the living organization itself.

4.3. Framework for Practical Field Application and Exploratory Configuration

To ensure that the exploratory sub-methods do not degenerate into static, bureaucratic accounting tools [14, 15, 16], the practical application of the toolbox explicitly promotes a non-linear progression guided entirely by the local context of use. Introducing the STT into an organization bypasses the external expert delivering a pre-packaged diagnostic report [49, 66]. Instead, the systems analyst functions strictly as an embedded facilitator, a "*change magician*", whose primary task is to cultivate a secure, non-hierarchical communication space that supports authentic systemic dialogue [7, 11], challenges latent power structures, and fosters critical reflection [10, 68, 73].

This "*change magician*" designation explicitly reflects a dual operational paradox detailed in the underlying theory of inquiry:

First, the facilitator is routinely tasked by management to address pre-conceived structural 'problems' and execute predetermined solutions, a restriction driven by management's own perceptual *'boundedness'* and cognitive blindness to the true scope of the human activity system. Second, to disrupt this constraint, the facilitator must navigate beyond a purely passive mirroring role, actively bringing forth alternative systemic perspectives and critical insights that the local actors would not otherwise entertain, thereby catalyzing them to reflect upon and challenge their own embedded assumptions and historical prejudices [90].

This intervention builds directly upon basic participatory tenets, and recent calls for participatory design as peace-making experiments in the small [92], which reframe the facilitator not as a passive or neutral actor, but as a visionary catalyst responsible for opening the participants' eyes to alternative possibilities and long-term consequences [91]. Rather than operating as a patronizing or prescriptive imposition, this active disruption functions as a democratic resource, equipping the unique local actors with the critical friction required to expose and transcend their own internalized operational biases.

Crucially, this role does not imply expert omnipotence; the facilitator cannot unilaterally dissolve entrenched structural asymmetries, but instead functions to support and catalyze the unique local actors as they articulate and assert authority over their own experienced realities. This intervention explicitly recognizes that *'local actors*' do not form a monolithic group; rather, they encompass diverse internal roles with potentially competing operational desires and asymmetric dynamics that must be transparently surfaced and negotiated. This critical focus aligns with foundational reflections on emergent futures [93], which reject grand technocentric projections in favour of re-emphasising deep local impacts built entirely upon the mundane, socio-material, and political realities of everyday work systems.

Furthermore, individual participants must not be reduced to static categories, typologies, or user caricatures; instead, the inquiry must honor the absolute uniqueness and emergent agency of each local actor as a prerequisite for professional competence [88].

Rather than relying on rigid project boundaries or standard corporate surveys, the facilitator coordinates semi-structured, participatory interviews supported by specialized templates embedded within the sub-methods [9, 16]. The resulting notes, schemas, rich pictures and interpretive visualizations serve as interactive mirrors, empowering workers to map out their own sense-making trajectories, informal coordination networks, and systemic friction points [73].

To support this open inquiry across the exploration spaces, the facilitator can draw upon a suite of specialized cross-cutting questionnaires. Rather than mapping rigidly to individual

dimensions, these instruments function as flexible diagnostic tools for the toolbox overall, compressing the framework's broad thematic breadth into experientially grounded entry points that allow the professional workforce to systematically evaluate sociotechnical options, expose hidden power dynamics, and safeguard localized operational autonomy. The core deployment configuration typically includes:

- *The Enterprise Questionnaire:* Activates the Contextual and Structural Base Space to map macro organizational variables.
- *The Sustainability Questionnaire:* Traces multi-dimensional cognitive, workforce, environmental and organizational resilience vectors.
- *The Activity Questionnaire:* Investigates situated behavioral patterns and hidden, informal user routines.
- *The Interaction Questionnaire:* Aligns practical task realities with cross-functional information coordination requirements.
- *The Organizational Learning Questionnaire:* Assesses the collective capacity of the actors to adapt and alter operational habits.
- *The Information and Cyber-Security Questionnaire:* Maps the convergence of formal governance matrices and local human adaptations.
- *The Socio-Technical Questionnaire:* Facilitates deep interpretive inquiry into job satisfaction and the psychological contract.
- *The Change-Potential Questionnaire:* Serves as a direct debate catalyst to identify transition friction and worker-governed autonomy.

The deployment, timing, and selection of these questionnaires remain optional and iterative [9, 16]. There use is determined collectively by the professional actors together with the facilitator, as their understanding of local structural boundaries evolves. By operationalising Cherns' principle of design-as-incomplete, this ensures that the co-designed outcomes do not freeze into static administrative structures, but instead feed continuously back into a permanent loop of radical self-reflexive auditing to adapt to the unfolding realities of the context of use.

4.4. Boundary Conditions: Functional Stupidity and the Sabotage of Excellence

To maintain the critical and pragmatic integrity of Contextual Systems Inquiry (CSI), the application of the Sociotechnical Toolbox (STT) must be understood within its contextual limitations. The toolbox functions neither as a corporate pacification mechanism nor as a therapeutic device designed to smooth over toxic institutional dynamics [9]. In practical application, a socio-technical inquiry remains operationally viable only if the host organizational reality supports a genuine, systemic pursuit of excellence. In the absence of an active commitment to professional autonomy and competence, attempting to apply the STT is a fundamental waste of analytical time. Without these prerequisites, the process easily degenerates into functional stupidity [62]. This state of organizational constraint reduces efforts to develop understanding, insight and reflection to a superficial compliance exercise that masks institutional dysfunction.

This boundary condition exposes a sharp systemic friction, highlighting the clash between a genuine pursuit of organizational excellence and the autocratic constraints of functional stupidity [62]. While professional autonomy and supported competence are prerequisites for excellence to flourish, they are frequently suppressed by aggressive managerialism and rigid compliance mandates [74]. When these conflicting forces collide, the inquiry environment becomes structurally constrained; top-down controls neutralize professional competence, reducing critical reflexivity to a superficial compliance exercise. Ultimately, establishing generative learning spirals is impossible in environments where institutional architectures are explicitly configured to conserve asymmetric power relations at the expense of human agency [63].

Because organizational excellence is an emergent property of facilitation of professional excellence and contextual competence in practice [72], establishing rigid, bureaucratic management architectures actively suppresses the localized know-how and subjective pre-knowledge (S) of the workforce [37, 78]. This internal failure cannot be resolved by external intervention; regardless of their proficiency with the STT, an outside facilitator cannot override deeply entrenched, punitive managerial practices [7, 9, 16, 72, 75].

If leadership utilizes technology primarily as an instrument of surveillance and autocratic control rather than a vehicle for workforce empowerment, the inquiry encounters an insurmountable barrier. The Information and Cyber-Security Questionnaire and the Change-Potential Questionnaire rely entirely on the honest articulation of the professional "*desires and motivations*" of the actors involved. The tools require an open exposure of informal workarounds. In a highly punitive or functionally constrained culture, actors within the system cannot safely disclose their experienced realities without risking immediate professional retaliation. Consequently, the STT includes an explicit boundary critique within its initial Context Analysis. If the facilitator uncovers a structural refusal to support individual competence, the inquiry cannot successfully proceed [7, 9, 16]. Ultimately, this boundary check reinforces the transdisciplinary stance that systems design is an exercise in human liberation rather than an instrument for managerial subjugation.

5. Experiential Field-Testing and Operational History

To ground its theoretical foundations in empirical validity, the STT has been subjected to continuous field-testing since the late 1990s, bypassing abstract modeling in favor of direct practitioner application within live workforces. Rather than an anecdotal retrospective or a statistical survey, this paper reflects over a cumulative archive of over 2,400 independent, qualitative action research projects built steadily over nearly three decades of continuous field practice. Each project was longitudinal and deeply iterative in character and often multiple weekly engagements, typically spanning four to ten months.

Throughout these engagements, the facilitator and employees participated in high-frequency field interactions, including weekly or semi-weekly observations and interviews. To support this deep contextual analysis, specific configurations of the cross-cutting questionnaires were introduced selectively based on emergent needs, rather than prescriptively deploying all instruments simultaneously. The aggregate scale of these intensive, locally situated iterations allows for a rigorous cross-case synthesis, illustrating how human activity systems actively navigate, adapt to, or disrupt digital transformations [63, 70, 71].

By deploying contextually adapted selections of topics and methods, the framework consistently empowers local actors to expose hidden structural contradictions between rigid corporate overlays and situated work-system realities.

This capacity to decode latent structural contradictions is evidenced across diverse sectors [12]:

- **Clinical General Practices (59 Cases):** By utilizing a broader set of analytical tools to map everyday conversations and technical data streams, the inquiries showed how new digital systems prioritized data-entry metrics over patient care. This directly disrupted the workforce's psychological contract and created severe cognitive overload.
- **Community Pharmacies (91 Cases):** Drawing on the toolbox's collection of methods, including Key Variance Analysis and Variance Management, the studies demonstrated that top-down technical updates actively undermined the quiet, implicit safety practices used by technicians to handle daily operational variations.
- **Small-Scale Retail Networks (87 Cases):** Integrating the Contextual Landscape lens within a wider mix of mapping methods proved how the final state of a retail workflow directly constrains the starting options of the next cycle. This approach allowed small businesses to adjust their routines without heavy analytical overhead.

Regardless of enterprise scale or industry sector, applying the toolbox consistently generates a continuous cycle of action and reflection [12]. Placing the STT into the hands of local professional actors empowers organizations to understand their own working environments accurately. By synthesizing this substantial body of experiential evidence, the framework distils decades of messy fieldwork into practical socio-technical design principles. This demonstrates how local user control can be used systematically to counteract workforce alienation across any automated domain.

5.1. Contemporary Transformations: Overlay Problems and VUCA Environments

As the technological landscape shifted between 2020 and 2023 toward a mix of hybrid remote-work infrastructure, decentralized collaborative platforms, and rapid algorithmic automation, the practical application of the toolbox transitioned from exploring localized activities to investigating systemic crises within highly unpredictable environments. A foundational milestone involved a multi-year inquiry based on interviews as well as deploying the Information and Cyber-Security Questionnaire across 471 professional actors in 259 public and private organizations. The findings revealed that security policies drafted in an executive vacuum operate as hostile overlays. To achieve primary operational targets, actors across all surveyed enterprises routinely deployed defensive workarounds. This confirms that cybersecurity functions as an intertwined social practice rather than an isolated technical mandate [13, 20].

This localized focus proved vital during the disruptions of modern volatile, uncertain, complex, and ambiguous (VUCA) environments [12]. Specifically, a 2021 inquiry into 40 UK organizations navigating pandemic disruptions applied Exploration Space a) (System Boundaries, Complexity & Vertical Analysis, and Organizational Learning) to expose a

persistent structural barrier [3, 4, 76]. The study revealed that autocratic administrative hierarchies actively stifled internal learning spirals by refusing to validate local operational autonomy [3, 4, 76]. Even when local actors possessed the situated pre-knowledge and adaptive risk-taking capacity required to respond to exogenous shocks, rigid governance mechanisms structurally constrained them from exercising this systemic agility [3, 4].

More recently, the framework has targeted the hidden trade-offs of hyper-automation and autonomous AI agency within knowledge-intensive domains like software engineering [19]. Deploying Exploration Space f) (Technical Possibilities) and Exploration Space g) (Implementation Diagnosis), these inquiries demonstrate that while generative AI tools offer immediate productivity gains, a top-down imposition risks causing severe skills erosion, structural dependence, and a loss of deep-context understanding among junior professionals.

To counteract these vulnerabilities, contemporary applications of the STT focus more explicitly on multiple categories of systemic robustness and sustainability when integrating AI into professional practices [49]. This aligns directly with the socio-technical foundations established in [19], where Industry 5.0 is defined not as a technocentric advancement, but as a paradigm shift toward harmony between technological and social systems. Under this view, 'smartness' must be evaluated from the perspective of unique, individual work roles [19].

This narrative is supported by contemporary socio-technical perspectives, which demonstrate that human-centricity and stakeholder agency function as critical structural inputs rather than optional add-ons, directly driving enterprise resilience [87]. By actively addressing how automated AI agency intersects with human activity systems [19], the framework moves Industry 5.0 literature from abstract theory to an operational reality. Its heuristics guide local actors to evaluate not just technical resilience, but cognitive, workforce, organizational, and environmental sustainability.

6. Conclusion: Proactive Evolution and the Horizon of the Unknown

The STT functions not as a reactive patch for technological defects, but as an anticipatory vehicle for continuous systemic inquiry and development. Frameworks built around a naive objectivist stance fail when confronting real-world complexity. To counteract this, the STT accommodates a reality in a permanent state of flux, expanding its conceptual boundaries before emergent disruptions are codified into formal management models. Rather than trying to artificially smooth over or eliminate the ambiguities and contradictions inherent in complex organizational spaces, the toolbox leverages its non-linear heuristics to support local actors in fluidly structuring their own uncertainty. This proactive adaptation ensures that systems development remains a forward-looking, contextually grounded intervention.

A three-decade record of multi-sector applications, spanning global banking, manufacturing, civic government, and micro-businesses, provides a resilient validation. This extensive volume of fieldwork illustrates that the toolbox functions as an adaptable infrastructure for continuous, collective human learning, rather than a framework reserved exclusively for large administrative budgets.

As contemporary human activity systems navigate an industrial horizon characterized by algorithmic invisibility, automated alienation, and the severe cognitive overburdens of hyper-automation, these core socio-technical principles remain steadfast. This resilience becomes an

ethical necessity when local actors confront the radical disruptions of Industry 4.0 or Industry 5.0 and the deployment of autonomous AI agency [19]. To prevent advanced solutions from functioning as hostile administrative overlays that alienate the workforce, contemporary applications of the STT enforce an explicit focus on systemic robustness and sustainability [49]. This offers a concrete methodological template to insulate human activity systems from algorithmic reductionism and ensure technical frameworks remain accountable to the workforce.

Integrating critical boundary critique with the interpretive auditing of daily routines allows the framework to evaluate technical choices against long-term sustainability. By promoting a dynamic application, the STT shifts sovereign authority over tool configuration directly to the local actors inhabiting the context of use. This flexible orientation drives meaningful organizational change, simultaneously cultivating localized professional competence and decision-making autonomy.

Decades of diverse fieldwork validate this exploratory architecture across micro-businesses, multinational corporations, and state agencies alike. This history proves that meaningful organizational change requires a continuous cultivation of supported professional competence and decision-making autonomy [7, 9, 16, 17, 78]. Ultimately, the STT advances transdisciplinary and participatory design by anchoring its extensive operational history in the rigorous practice of relevance [70]. It operates as an evolving, flexible toolbox that empowers human activity systems to systematically structure uncertainty, maintain a vital double-helix relationship between theory and practice, and democratically co-design their own sustainable socio-technical futures. Ultimately, the toolbox proves that the most resilient sociotechnical frameworks and re-design of effective work-practices are those that trust the practical wisdom of the human beings who run them.

Declaration on Generative AI

During the preparation of this manuscript, the author utilized Google Gemini (Gemini 1.5 Pro) to improve the readability, narrative structure, and thematic cohesion of the text. The author reviewed, edited, and verified all outputs generated by the AI assistant and assume full accountability for the accuracy, originality, and integrity of the final text and its references.

References

[1] Amanollahnejad, A., Fosso-Wamba, S., Shabbir, M. S., & Pakseresht, A. (2026). Aligning Socio-Technical Systems: Rethinking AI Adoption and Digital Transformation in SMEs. *Information Systems Management*, 43(2), 103–117. https://doi.org/10.1080/10580530.2025.2612175

[2] Argyris, C. (1990). *Overcoming Organisational Defenses – Facilitating Organisational Learning*. Boston: Allyn and Bacon.

[3] Atanassova, I., & Bednar, P. (2024). Socio-technical foundations of sustainable business practices during VUCA. *CEUR Workshop Proceedings*, 3857, 144–160. https://ceur-ws.org/Vol-3857/paper15.pdf

[4] Atanassova, I., Bednar, P., Khan, H., & Khan, Z. (2025). Managing the VUCA environment: The dynamic role of organisational learning and strategic agility in B2B versus B2C firms. *Industrial Marketing Management*, 125, 12–28.

[5] Bateson, G. (1972). Steps to an ecology of mind. Chicago: University of Chicago Press
[6] Baxter, G., Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering, *Interacting with Computers* (23), pp. 4–17 (2011).
[7] Bednar, P. M. (2000). A contextual integration of individual and organizational learning perspectives as part of IS analysis. *Informing Science: The International Journal of an Emerging Transdiscipline,* 3(3), 145–156.
[8] Bednar, P. M. (2007). Individual emergence in contextual analysis. *Systemica*, 14(1–6), 23–38.
[9] Bednar, P. (2022). *Sociotechnical Toolbox*. (5th ed.) Craneswater Press.
[10] Bednar, P. M., & Ojukwu, I. (2020). Organizational change as an example of socio-technical design: Action research frameworks. In P. M. Bednar, I. Bider, & S. Kowalski (Eds.), Proceedings of the 6th International Workshop on Socio-Technical Perspective in IS Development (STPIS 2020) *CEUR Workshop Proceedings*, Vol. 2789, pp. 89–102. CEUR-WS.org.
[11] Bednar, P. M., & Sadok, M. (2016). Facilitating organizational change: A collaborative, open systems perspective. In P. M. Bednar, I. Bider, & S. Kowalski (Eds.), Proceedings of the 2nd International Workshop on Socio-Technical Perspective in IS Development (STPIS 2016) *CEUR Workshop Proceedings*, Vol. 1604, pp. 45–59). CEUR-WS.org.
[12] Bednar, P. M., Sadok, M., & Shiderova, V. (2014). Socio-technical toolbox for business analysis in practice. In L. Caporarello, B. Di Martino, & M. Martinez (Eds.), *Smart Organizations and Smart Artifacts* (pp. 219–227). Springer.
[13] Bednar, P. M., Sadok, M., & Welch, C. (2020). A socio-technical perspective to counter cyber-enabled industrial espionage. *Security Journal*, 33(3), 444–460.
[14] Bednar, P. and Welch, C. (2005) IS, Process and Organizational Change and their Relationships to Contextual Dependencies. 13th European Conference on Information Systems, 2005 p.1466-1476.
[15] Bednar, P. & Welch, C. (2007). A double helix metaphor for use and usefulness in informing systems. *Informing Science* 10, pp. 273–294
[16] Bednar, P. M., & Welch, C. (2008). Bias, misinformation and the paradox of neutrality. *Informing Science: The International Journal of an Emerging Transdiscipline,* 11, 85–106.
[17] Bednar, P. & Welch, C. (2012). Critical systemic thinking as a foundation for information systems research practice. *Journal of Information, Communication and Ethics in Society* (2012) 10 (3): 144–155. https://doi.org/10.1108/14779961211261058
[18] Bednar, P. M., & Welch, C. (2018). Balancing stakeholder interests: Sociotechnical perspectives on smart working practice. In A. Lazazzara, R. Cuel, & S. Za (Eds.), *Business Process Analysis and Change Management* (Vol. 24, pp. 115–130). Springer.
[19] Bednar, P.M., Welch, C. (2020). Socio-Technical Perspectives on Smart Working: Creating Meaningful and Sustainable Systems. *Inf Syst Front* 22, 281–298. https://doi.org/10.1007/s10796-019-09921-1
[20] Bednar, P. M., Welch, C., & Sadok, M. (2023). IS and cybersecurity practice: Avoiding self-sabotage. In P. M. Bednar, I. Bider, & S. Kowalski (Eds.), Proceedings of the 9th International Conference on Socio-Technical Perspective in IS Development (STPIS 2023) *CEUR Workshop Proceedings*, Vol. 3598, pp. 138–145.

[21] Becker, C. (2023). Insolvent: How to reorient computing for just sustainability. The MIT Press. https://direct.mit.edu/books/oa-monograph/5594/InsolventHow-to-Reorient-Computing-for-Just
[22] Beer, S. (1985). *Diagnosing the System for Organizations*. John Wiley, London and New York.
[23] Cabitza, F., Jurman, G., Molinari, F. Bellazzi, R. (2026), Why almost all ML models for medicine are wrong, and what we need for evidence-based medical AI. *Int. J. Med. Inform.*, 219 (2026).
[24] Cecez-Kecmanovic, D. (2025). Ethics in the world of automated algorithmic decision-making–A posthumanist perspective. *Information and Organization*, 35(3), 100587. https://doi.org/10.1016/j.infoandorg.2025.
[25] Checkland, P. (1981). *Systems thinking, systems practice*. John Wiley & Sons.
[26] Checkland, P., & Scholes, J. (1990). *Soft systems methodology in action*. John Wiley & Sons.
[27] Checkland, P. (1999). Soft systems methodology: A 30-year retrospective. *Systems Research and Behavioral Science*, 16(S1), S11–S58.
[28] Checkland, P., & Holwell, S. (1998). *Information, Systems and Information Systems*. Wiley.
[29] Cherns, A. (1976). Principles of Socio-technical Design. *Human Relations*, Vol. 2, 783-792
[30] Ciborra, C. (2002). *The labyrinths of information: Challenging the wisdom of systems*. Oxford University Press.
[31] Dolata, M., Feuerriegel, S., & Schwabe, G. (2022). A sociotechnical view of algorithmic fairness. *Information Systems Journal*, 32(4), 754–818. https://doi.org/10.1111/isj.12370
[32] D'souza, S., Introna, L.D. Recovering Aristotle's Practice-Based Ontology: Practical Wisdom as Embodied Ethical Intuition. *J Bus Ethics* 189, 287–300 (2024). https://doi.org/10.1007/s10551-023-05371-7
[33] Friis, S. (1991). *User Controlled Information Systems Development – problems and possibilities towards Local Design Shops*. Information and Computer Science, Lund University Publications, Sweden.
[34] Hirschheim, R. and Klein, H.K. (1994). Realizing emancipatory principles in information systems development: the case for ETHICS. *MIS Quarterly*, March 1994.
[35] Jackson, M. A. (1983). *System development*. Prentice Hall.
[36] Keramidis, P., & Shollo, A. (2026). The realisation of IS business value: a value-reflexive perspective. *European Journal of Information Systems*, 35(2), 280–300. https://doi.org/10.1080/0960085X.2025.2607449
[37] Langefors, B. (1966). *Theoretical analysis of information systems*. Studentlitteratur.
[38] Markus, M. L., & Robey, D. (2004). Why stuff happens: Explaining the unintended consequences of using it. In K. V. Andersen & M. T. Vendelø (Eds.), *The past and future of information systems* (pp. 61–93). Elsevier Butterworth-Heinemann.
[39] Mathiassen, L., Munk-Madsen, A., Nielsen, P. A., & Stage, J. (2000). *Object oriented analysis and design*. Marko Publishers.
[40] Maturana H. R. & Varela F. J. (1980) *Autopoiesis and cognition: The realization of the living*. Reidel, Boston.
[41] Maturana H. R. & Varela F. J. (1987) *The tree of knowledge: The biological roots of human understanding*. Shambhala, Boston.
[42] Morgan, G. (1986). *Images of organization*. SAGE Publications.
[43] Mumford, E. (1983; 1985). *Designing human systems: The ETHICS method*. Manchester Business School.

[44] Mumford E. (1999). *Dangerous Decisions: Problem Solving in Tomorrow's World*. Dordrecht, NL: Kluwer Academic Publishers.
[45] Mumford, E. (2003). *Redesigning Human Systems*. IRM Press, London University Press, Cambridge.
[46] Mumford, E. (2006). The story of socio-technical design: reflections on its successes, failures and potential. *Information Systems Journal*, 16, pp 317-342.
[47] Nissen, H-E. (1984). 'Acquiring knowledge of Information Systems – Research in a Methodological Quagmire,' in Mumford et al (1984). Research Methods in Information Systems. *Proceedings of the IFIP WG 8.2 Colloquium*, Manchester Business School, 1984, pp 39-52 .North Holland, Amsterdam.
[48] Nissen, H-E. (2002). Challenging traditions of inquiry in software practice. In Y. Dittrich, C. Floyd, & R. Klischewski (Eds.), *Social thinking – software practice* (pp 69-90). Cambridge Mass: MIT Press
[49] Pascarella, L., & Bednar, P. M. (2022). Systemic sustainability as multiple perspective analysis. In R. Cuel, D. Cortese, & M. L. Toraldo (Eds.), *Exploring Digital Resilience* (Vol. 53, pp. 69–86). Springer.
[50] Pasmore, W., Winby, S., Mohrman, S. A., & Vanasse, R. (2019). Reflections: Sociotechnical Systems Design and Organization Change. *Journal of Change Management*, 19(2), 67–85. https://doi.org/10.1080/14697017.2018.1553761
[51] Sadok, M., & Reid, I. (2025). An exploration into the requirements and responsibilities of CISO roles: Balancing art with science. In M. Topuzovska Latkovikj, P. M. Bednar, M. Rajanen, J. Kävrestad, H. Vallo Hult, & A. Elbanna (Eds.), Proceedings of the 11th International Conference on Socio-Technical Perspectives in Information Systems (STPIS 2025) *CEUR Workshop Proceedings*, Vol. 4134, pp. 78–92.
[52] Stahl, B. C. (2026). A framework for value sensitive design in socio-technical digital ecosystems. *European Journal of Information Systems*, 35(2), 324–342. https://doi.org/10.1080/0960085X.2025.2595915
[53] Radnitzky, G. (1973). *Contemporary schools of metascience* (3rd, enlarged edition.). Chicago: Humanities, Press / Henry Regnery Company.
[54] Ulrich, W. (1983). *Critical heuristics of social planning: A new approach to practical philosophy*. Haupt.
[55] Walsham, G. (1995). Interpretive case studies in IS research: Nature and method. European *Journal of Information Systems*, 4(2), 74–81. https://doi.org/10.1057/ejis.1995.9
[56] Walsham, G. (2012). Are we making a better world with ICTs? Reflections on a future agenda for the IS field. *Journal of Information Technology*, 27(2), 87–93. https://doi.org/10.1057/jit.2012.4
[57] Weick, K. (1995). *Sensemaking in organizations*. Thousand Oaks: Sage Publications
[58] Vickers, G. (1984). *Human systems are different*. London: Harper & Row.
[59] Whitaker, R. (2007). Applying phenomenology and hermeneutics in IS design: A report on field experiences. In H-E. Nissen, P. M. Bednar, & C. Welch (Eds.), Use and design in IS: Double helix relationships? Monograph in *Informing Science: The International Journal of an Emerging Transdiscipline,* 10, 63-96.
[60] Wittgenstein, L. (2009). *Philosophical investigations*. G. E. M. Anscombe, P. M. S. Hacker, & J. Schulte, Trans.; 4th ed. Wiley-Blackwell.

[61] Zimmer, M. P., Vassilakopoulou, P., Grisot, M., & Niemimaa, M. (2026). Embracing contrarian thinking: Value-reflexive research for a better world. *European Journal of Information Systems,* 35(2), 165–177. https://doi.org/10.1080/0960085X.2026.2648981
[62] Alvesson, M. and Spicer, A. (2012), A Stupidity-Based Theory of Organizations. *Journal of Management Studies*, 49: 1194-1220. https://doi.org/10.1111/j.1467-6486.2012.01072.x
[63] Alvesson, M. and Spicer, A. (2026), Critical Management Studies: From One-Dimensional Critique to Three-Dimensional Scepticism. *J. Manage. Stud.*, 63: 1637-1660. https://doi.org/10.1111/joms.13256
[64] Ackoff, R, and Emery, F E (1972). *On Purposeful Systems*. Chicago: Aldine-Atherton
[65] Ackoff, R (1974). *Redesigning the Future: A Systems Approach to Societal Problems*. New York: Wiley.
[66] Ashby, W R (1956). *An Introduction to Cybernetics*, London: Chapman & Hall
[67] Avison, D and Fitzgerald, G (1995; 2006). *Information Systems Development: Methodologies, Techniques and Tools*. Maidenhead: McGraw-Hill
[68] Avison, D.E., Lau, F., Myers, M.D. and Nielson, P.A. (1999). Action Research. *Communications of the ACM*, 42(1), 94-97.
[69] Bertalanffy, L von (1968). *General Systems Theory: Foundations, Development, Applications,* New York: George Braziller.
[70] Benbasat, I and Zmud, R W (1999). Empirical research in information systems: The practice of relevance. *MIS Quarterly*, 23(1), 3-16.
[71] Bergvall-Kåreborn, B. (2006). Diversity is in the Air – It is time to Challenge our Weltanschauung. *Systemist*, 28(2), 13-25.
[72] Bjerknes G, Dahlbom B et al (eds). (1990). *Organizational Competence in Systems Development*, Lund: Studentlitteratur.
[73] Borodzicz, E P (2004). The Missing Ingredient is the Value of Flexibility, *Simulation Gaming*. 35, 414-426.
[74] Brunsson, N (2002). *The Organization of Hypocrisy: Talk, Decisions and Actions in Organizations*, Copenhagen: Copenhagen Business School Press.
[75] Churchman, C W (1979). *The Systems Approach and Its Enemies*. New York: Basic Books.
[76] De Zeeuw, G (2007). Knowledge Acquisition in Changing Realities, *Kybernetes*, 26 (6-7), 837-847.
[77] Feynman, R.P. (1974). CargoCult Science: Some remarks on science, pseudoscience and learning how to not fool yourself. Caltech's 1974 Commencement address. *Engineering & Science*, 37(7), 10-13.
[78] Foerster, H von (1972). Responsibilities of Competence, Paper 223, Biological Computer Laboratory, University of Illinois, adapted from keynote address to Conference of the American Society for Cybernetics, 9 December 1971, in *Journal of Cybernetics*, 2(2), 1-6.
[79] Hägerfors, A (1994). *Co-learning in Participative Systems Design*, Dept. of Informatics, Lund: Lund University.
[80] Jayaratna, N. (1994). *Understanding and Evaluating Methodologies: NIMSAD - A Systematic Framework*. London: McGraw-Hill.
[81] Klein, H. K. (2006). 'The phenomenological and hermeneutic "Turns": the significance of Husserl, Schutz' and Gadamers ideas for Information Systems

research.' Third Leverhulme Lecture, University of Salford, Informatics Research Institute, 15th November, 2006.
[82] Myers, M D and Klein, H K (2011). A Set of Principles for Conducting Critical Research in Information Systems. *MIS Quarterly*, 35 (1), 17-36.
[83] Peirce, C S (1905/1998). What Pragmatism Is. In *The Essential Peirce, Vol.2. The Peirce Edition Project.* (Bloomington IN: Indiana University Press), 331-345.
[84] Radnitzky, G (1970). *Contemporary Schools of Metascience.* Gothenburg: Akademiforlaget.
[85] Sandström, G (1985). *Towards Transparent Data Bases - How to interpret and act on expressions mediated by computerized information systems.* Lund: Chartwell-Bratt Studentlitteratur.
[86] Thakurta, R. (2026). Technology-Driven Talent Management Practices—A Sociotechnical Framework. *Systems Research and Behavioral Science* 43, no. 1: 362–386. https://doi.org/10.1002/sres.3176.
[87] Farivar, F., Klarin, A. and Kanani-moghadam, V. (2026) 'Industry 5.0: A socio-technical system perspective on human agency and institutional legitimacy', *Journal of Management & Organization*, 32(4), pp. 1168–1189. doi:10.1017/jmo.2026.10095.
[88] Bednar, P. M., & Welch, C. (2005). Critical Systemic Thinking – or The Standard Engineer in Paris. In *Proceedings of the 4th European Conference on Research Methods in Business and Management*, Université Paris-Dauphine, France, 21–22 April 2005.
[89] Wood-Harper, A. T., Antill, L., & Avison, D. E. (1985). *Information Systems Definition: The Multiview Approach.* Oxford: Blackwell Scientific Publications.
[90] Bednar, P. (2016). *Complex methods of inquiry: structuring uncertainty.* Lund University Press.
[91] Ehn, P. (2008). Participation in design things. *Proceedings of the Tenth Anniversary Conference on Participatory Design*, 92–101.
[92] Ehn, P. (2025). Participatory design as peace-making experiments in the small. In R. C. Smith, D. Loi, H. Winschiers-Theophilus, L. Huybrechts, & J. Simonsen (Eds.*), Routledge International Handbook of Contemporary Participatory Design* (pp. 292–293). New York: Routledge.
[93] Bødker, S., & Ehn, P. (2025). Afterthoughts for an Emergent Future. In R. C. Smith, D. Loi, H. Winschiers-Theophilus, L. Huybrechts, & J. Simonsen (Eds.), *Routledge International Handbook of Contemporary Participatory Design* (pp. 291–293). Abingdon: Routledge.
[94] Nissen, H.-E. (2007). Using Double Helix Relationships to Understand and Change Informing Systems. In H-E. Nissen, P. M. Bednar, & C. Welch (Eds.), Use and Redesign in IS: Double Helix Relationships? *Monograph in Informing Science: The International Journal of an Emerging Transdiscipline*, 10, 21–62.
[95] Berger, P. L., & Luckmann, T. (1967). *The social construction of reality: A treatise in the sociology of knowledge.* Anchor Books.
[96]