Communicating Strategic Intent with Systemigrams: Application to the Network-Enabled Challenge

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ABSTRACT

The U.K. Ministry of Defense (MoD) has mandated the development of a network enabled capability (NEC) across all of defense, aimed at producing agile military and nonmilitary effects via a network of networks. This paper provides an overview of NEC, representing it as a complex human activity system of systems (SoS), analysis of which cannot rely on purely traditional reductionist engineering approaches, requiring instead a soft-systems engineering approach. A literature review is then provided, covering nontraditional systems methodologies of the past 25 years, highlighting the more recent trend towards multimethodological practice. The paper introduces the systemic diagram, or systemigram, conceptual model, explaining its evolution from a form of visual language to its use as an appreciative learning system in a soft-systems methodology. Using the written prose of MoD policy makers, a systemigram model is constructed which represents the NEC concept, providing a systemic visualization of its complexity and an elucidation of the key SoS attributes of emergence, hierarchy, and boundary. Finally, the NEC systemigram is used in an example storyboarding technique, demonstrating its utility as a platform for stakeholder dialog leading towards a refined model that reflects a deeper understanding of NEC strategy. © 2007 Wiley Periodicals, Inc. Syst Eng 10:309–322, 2007

Key words: BSSM; multimethodology; NEC; SoS; SSM; systemigram

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1. INTRODUCTION

To date, much attention and no small amount of funding has been paid to the study and development of Network Enabled Capability (NEC). However, there appears to be no single definition for the concept. In describing NEC, U.K. Ministry of Defense (MoD) Joint Service Publication (JSP) 777 [2005b] states:

… Our understanding of NEC will continue to develop, so it is important not to constrain the future direction of NEC by an overly-restrictive definition. … Networked Enabled Capability offers decisive advantage through the timely provision and exploitation of information and intelligence to enable effective decision-making and agile actions. NEC will be implemented through the coherent and progressive development of Defence equipment, software, processes, structures, and individual and collective training, underpinned by the development of a secure, robust, and extensive network of networks.

Unlike the more network-centric approach as embodied in the U.S. DoD Network Centric Warfare (NCW), NEC is described as a complex sociotechnical capability that should be considered holistically across all defense Lines of Development (Training, Equipment, Personnel, Information, Doctrine & Concepts, Organization, Infrastructure, and Logistics). Checkland [1993] would classify NEC as a human activity system (HAS) by virtue of its heavy human influence and social interaction. JSP 777 [2005b] describes NEC development as centered around seven high-level goals which in turn are broken down into specific objectives, each with an owner “… responsible for delivering, in conjunction with other stakeholders, the outputs required to achieve their objectives.” In specifying NEC requirements, Alston [2003] proposes an “ends, ways, means” approach wherein analysis proceeds sequentially starting with the desired end state, through a statement of how this will be achieved, and ending with a statement of what equipment is required. The language of each of these approaches points to reductionist, goal-oriented thinking, the hallmark of a traditional positivist paradigm (a philosophical world view that objective knowledge can always be achieved; see Mingers [2004]). The philosophical assumptions associated with the positivist paradigm and its weakness in the treatment of complex systems have been covered extensively in the literature of the past 25 years. Checkland [1993] reiterates the inadequacy of a traditional positivist approach in addressing soft problems based on a number of case studies. Mingers [2004] discusses the move away from a positivist paradigm in the practice of management science/operational research (MS/OR). The positivist paradigm is particularly ill-suited for the large HAS. Checkland [1993, p. 256] writes: “… We were driven to conclude that there is a large class of soft problems for which the language of ‘ends’ and ‘means’ is inappropriate, problems concerned not with achieving goals but with managing on-going relationships through time.” In the early system definition phases of a project, strategic vision and user needs must be captured and accurately translated into requirements, establishing the operational context for system development. In the case of NEC, feeding this translation process are competing social elements arising from the multitude of stakeholder views to be collected, analyzed, understood, and integrated into a set of coherent requirements faithful to the perceived intent of the original strategy. Within this dynamic and complex NEC SoS, what Senge [1990] calls “dynamic complexity” and Ackoff [1981] politely calls a “mess,” one strives to understand and effectively communicate NEC strategy to project teams.

This paper contends that communication of NEC strategy begins with a proper visualization of its complexity using a systemic diagram, or systemigram conceptual model. Following a literature review of existing nontraditional systems methodologies, the paper discusses the evolution of the systemigram technique and provides justification for its application to NEC. A conceptual model of NEC strategy is then developed using the systemigram as part of a broader soft-systems methodology. The paper concludes with a storyboarding technique in which the systemigram is decomposed into several major themes, or strands, intended for use in a stakeholder dialog to elucidate key issues for debate resulting in a refined systemigram model to be used in communicating NEC strategy.

2. REVIEW OF THE LITERATURE

The number of nontraditional systems methodologies (defined herein as methodologies founded on other than a positivist/reductionist paradigm) in the literature appears to have stabilized following a period of rapid growth from the mid-1980s through the 1990s. Mingers and Rosenhead [2004] provide a summary of such methodologies, also known as “problem structuring methodologies” in MS/OR circles, in practice. Several of these methodologies are summarized in Table I with references. These methodologies are in contrast to the more positivist techniques currently employed in systems engineering practice and discussed primarily in the U.S. literature such as: Needs Analysis, Hierarchy of Objectives, or Strategies to Tasks (see Thaler [1993]; Kent and Thaler [1993]).
In other writings, Gu and Tang [2005] discuss a methodology of “meta-synthesis” founded on Eastern philosophy. The meta-synthesis approach is designed to address unstructured problems using a combination of soft and decision support methods attempting to synthesize experts, knowledge databases, and computers via networking. Meta-synthesis along with many of the approaches in Table I bring with them considerable
3. SYSTEMIGRAMS—EVOLUTION AND RELEVANCE TO NEC

The evolution of systemigrams may be considered in three phases: its development as a form of visual language, its adaptation as a methodology for business architecting, and its refinement as an appreciative learning system. In Phase 1, development of the technique concentrated on the graphical portrayal of structured prose. The first application of the method involved support to a European R&D project [Boardman, 2005]. In this instance, the systemigram was employed to communicate business strategy to a project team using written prose found in a project notebook whose sole author had left the company. Inspired by Checkland’s formal HAS model [1993], Boardman proposed that diagrams, which could be regarded as systems in their own right, were the way forward, and that the components of these systemic diagrams, or systemigrams, would come directly from the author via his/her writings. Diagrams that capture concepts are not new (e.g., concept diagrams, concept mapping, fishbone diagrams, influence diagrams, and even the original flow charts). However, these other diagram types are largely memoryless, capturing the immediacy of prose but then forgetting and moving on to the next local piece of knowledge, making it more difficult to find longer thought threads since they concentrate on linear thinking rather than holistic thinking. Senge’s diagrams [Senge, 1990] are a possible exception to this, but these are usually kept deliberately small with the totality of the language conveyed by the diagram difficult to comprehend. As they are assembled in the spirit of systems (e.g., parts, relationships, wholes, emergence, flows, inputs, outputs, transformations, process, and networks), and used as appreciative learning systems within a soft systems methodology, systemigrams are a powerful medium for systems thinking and systems practice.

The systemigram was intended to convey a synergy of prose and pictures, thus embodying the best features of each. A scientific basis for such synergy exists in the field of neuropsychology [Paivio, 1991; Mazoyer et al., 2002]. Critically, the systemigram must be faithful to the text whence it came; recovery of the original prose by inspection of the diagram a key requirement. This imposes certain rules upon both prose and diagram as follows:

Rules for Prose
1. Address strategic intent, not procedural tactics.
2. Be well-crafted, searching the mind of reader and author.
3. Facilitation and dialogue with stakeholders (owner/originator of strategic intent) may be required to create structured text.
4. Length variable but less than 2000 words; scope of prose must fit scope of resulting systemigram

Rules for Graphic
1. Required entities are nodes, links, inputs, outputs, beginning, end (similar in purpose to Horn’s [1998] morphological primitives).
2. Sized for a single page.
3. Nodes represent key concepts, noun phrases specifying people, organizations, groups, artifacts, and conditions.
4. Links represent relationships and flow between nodes, verb phrases (occasional prepositional phrases) indicating transformation, belonging, and being.
5. Nodes may contain other nodes (to indicate break-out of a document or an organizational/product/process structure.
6. For clarity, the systemigram should contain no crossover of links.
7. Based on experience, to maintain reasonable size for presentation purposes, the ratio of nodes to links should be approximately 1.5.
8. Main flow of systemigram is from top left to bottom right.
9. Geography of systemigram may be exploited to elucidate the “why,” “what,” “how” in order to validate the Transformational aspect of the systemic model.
10. Color may be used to draw attention to sub-families of concepts and transformations.

Phase 2 involved the adaptation of systemigrams by Alison Boardman [Boardman, 2005] to a business architecting approach called the Boardman Soft Systems Methodology (BSSM). Like SSM from which it was inspired, BSSM is firmly rooted in practical application. Unlike SSM, however, BSSM is more narrowly focused on those practicalities of project management associated with concurrent engineering (CE) in the modern extended enterprise. Boardman [1994] describes the use of the systemigram in developing a process model unifying engineering and project management activities. Boardman and Cole [1996] used the BSSM approach for the representation and analysis of process knowledge as a platform for process improvement in capital goods manufacture. The essence of BSSM is threefold.

First, taking a business or technical process approach has considerable virtue:

- It relates powerfully and compellingly to what people do.
- It yields a business process architecture (BPA) of the enterprise.
- It can accommodate an extended enterprise perspective, integrating the component BPAs into a system of systems (SoS) view.
- It can provide a baseline from which to launch development projects.
- It animates an otherwise sterile library of processes into an active and adaptive portfolio of competence.
- It provides a benchmark for demonstrating and maturing competence of the enterprise.

- It affords a profile by which human skills, knowledge and aptitudes can be successfully aligned with tasks.

Second, the BPA can be treated in exactly the same manner as a product architecture, relevant to lifecycles, reviews, tradeoffs, and simulation. It is important to emphasize that systemigrams are not architectures themselves, but rather they can provide a neutral and common environment for comparing and aligning enterprise architectures.

The following case studies [Boardman, 2006] in which systemigrams have sought to capture “system” architectures include: UK Rail Industry Economic Architecture, UK Digital Terrestrial TV Strategy, and Daily Mail and General Trust plc Enterprise portfolio strategy. Systemigrams have also been employed in the analysis of SoS complexity in the USAF 2020 Combat Strategy [Boardman and Wilson, 2005]. Having established BSSM as a viable methodology for the modeling and improvement of business processes, Phase 3 shifted emphasis to refinement of systemigrams as a learning system facilitated through the technique of storyboarding. In this method, the composer of the systemigram creates a storyboard using carefully selected scenes which are subnets of the systemigram. The storyboarding helps to convey the message of the systemigram, together with the message that the author of the original text intended, to a wider audience. In the systemigram, advantage is taken of color, flow, and texture to create scenes (another connection may be made here with Horn’s [1998] use of Gestalt principles of perception and topologies to convey meaning) which represent key parts of the message which can only be amplified by having the right people (stakeholders) listen to the systemigram story. This drilling down can be continued for as long as required or until the messages begin to fail the original top-level requirements for the original text’s systemigram interpretation. In principle, this drill down technique can be part of a requirements management approach in which the key concepts (nodes) are now increasingly circumscribed by relationships with peers, parents, and “offspring.” Such an approach was used in the case study for the BBC in the subject of digital television [Boardman, 2006].

The use of BSSM systemigrams to address NEC may be justified in terms of its validity, relevance, and pragmatic merit. Validity is established in the proper consideration of NEC as a complex sociotechnical HAS requiring a soft-systems treatment. Its relevance lies in the fact that BSSM was specifically designed to address issues associated with ill-structured problems in concurrent engineering, extended enterprise, and project management domains [Ramsay, Cole, and Boardman,
4. APPLICATION OF BSSM AND SYSTEMIGRAMS TO NEC

4.1. The Problem Situation

Following the attacks on September 11, 2001, the UK revisited the standing Strategic Defense Review (SDR) of 1998 and published the SDR New Chapter (SDR-NC) in 2002 [UK MoD, 2003b] to address the changing security environment brought on by the global war on terror. The Defense White Paper, “Delivering Security in a Changing World” [UK MoD, 2003a], built on the SDR-NC by laying out the policies for NEC, realized that operations against international terrorism require increased precision and rapid delivery of military effect, capabilities achieved only through a networked force employing shared situational awareness. A number of policy and guidance initiatives have spun off from the SDR-NC, all feeding the future UK Operational Concepts for Space, Air, Land, Maritime, and Logistics, setting the operational context for NEC. These various operational concepts must adopt NEC as an enabling capability crossing all Defense Lines of Development (Training, Equipment, People, Infrastructure, Doctrine, Organization, Information, and Logistics) to remain coherent with the overall UK Defense Strategy. This is no small order indeed and represents an unstructured view of the problem situation.

4.2. Structured Text

The following structured text was developed from the authors’ review of the writings found within the following open-source publications: Defence White Paper [UK MoD, 2003], Joint Doctrine Note 1/05 [UK MoD, 2005a], JSP 777 [UK MoD, 2005b], and Alston [2003]. The structured text constitutes an integrated rich text formulation of stakeholder world views of NEC strategy embodied in these papers.

Structured Text

UK Defense policy directs the development of future UK Operational Concepts for Land, Air, Space, Maritime, and Logistics. These operational concepts are guided by the UK Joint Vision, Joint High-Level Operational Concept, Effects-Based Operations Concept, and the Defense White Paper. The operational concepts are informed by emerging concepts such as NEC, to achieve the overall UK Defense Aim: “to deliver security for the people of the United Kingdom and the Overseas Territories by defending them, including against terrorism; and to act as a force for good by strengthening international peace and stability.” NEC enables a flexible acquisition strategy to establish coherent acquisition programs, these programs adopting an incremental approach to realize rapid technology insertion to achieve a net-ready force which exploits a network infrastructure to enable shared awareness. Shared awareness underpins flexible working to deliver synchronized effects that address the dynamic mission which is undertaking the defined UK military tasks to achieve military and non-military effects. NEC requires an information infrastructure to provide secure and assured information access to support the network infrastructure and facilitate shared awareness. NEC also employs Effects Based Planning across Government which requires a dynamic planning system supported by distributed tools and models to manage Agile Mission Groups, thus enabling Flexible Working. NEC improves equipment integration of weapon systems, intelligence, surveillance, target acquisition and reconnaissance systems, and command and control nodes to facilitate the Agile Mission Groups. NEC also enables Networked Support across public and industry to sustain Agile Mission Groups used to enable Flexible Working.

4.3. Systemigram Design

The above structured text is reflected in Figures 1 and 2. Figure 1 represents the higher-level systemigram model of the NEC context discussed above, showing how NEC informs the operational concept development used to achieve the overall UK Defense Aim. The systemigram in Figure 2 represents a magnified version of the NEC Emerging Concepts node of Figure 1. Five main strategy “strands” derived from the structured text are indicated by numbers in Figure 2, although one is encouraged to take advantage of color as well to highlight the strands. The following core NEC themes as defined in the NEC Conceptual Framework [Alston, 2003] are included in the systemigram: Flexible Acquisition, Information Infrastructure, Secure and
Figure 1. NEC context.

Figure 2. NEC Systemigram.
Assured Information, Effects-Based Planning, Networked Support, Shared Awareness, Agile Mission Groups, Flexible Working, and Synchronized Effects. Eight of the core themes cover equipment capability and one the acquisition process.

A story-boarding technique should now be used in which a systemigram slide show is utilized to engage the stakeholder audience in an iterative process of meaningful dialogue/debate by walking through each of the strategy strands. This activity of stakeholder interaction via storyboarding is at the heart of the systemigram technique, reflecting its power as a conceptual, appreciative learning system. This also places no small amount of responsibility on the facilitator as the technique itself involves a prudent application of artful communications (both passive and active), acknowledging the cultures of the intended audience. For this reason there are no strict rules to storyboarding; the story can be told in a variety of ways but all have the same generic format: to create a storyboard using carefully selected scenes which are subnets of the systemigram. Storyboarding helps convey the message of the systemigram, together with the message that the author(s) of the original text intended, to a wider audience. The following paragraphs provide one potential story-boarding technique for the NEC systemigram in which advantage is taken of specific strategy strands highlighted numerically.

Strand 1, shown in Figure 3, develops the Flexible Acquisition core theme of NEC. Inclusive Flexible Acquisition is a coordinating process across the MoD, industry, and other government departments (OGDs) to establish coherent acquisition programs. This is the most pressing and difficult issue of NEC to overcome as it directly addresses the legacy “stovepiped” organization and thinking of various program offices within the MoD procurement organization. An incremental acquisition approach is necessary to minimize risk and realize rapid technology insertion in an unpredictable funding environment. This equipment is necessary to achieve a net-ready force which may exploit a network ready infrastructure consisting of C4ISR systems such as the Defense Information Infrastructure (DII), SKYNET 5, Cormorant, Joint Operational Picture (JOP), Bowman, and the Joint C2 Support System (JC2SS) to enable Shared Awareness, with secure and assured information providing the underpinning support. In turn, Shared Awareness underpins Flexible

![Figure 3. Flexible acquisition strand.](image-url)
Working, the ability for assets to rapidly reconfigure to meet changing mission needs. Through Flexible Working, Synchronized Effects between mission groups may be delivered to address the very dynamic nature of asymmetric warfare. Thus, the UK military may undertake defined Military Tasks to achieve both military and nonmilitary (political, economic) effects.

Strand 2 in Figure 4 shows an information infrastructure is required to provide secure and assured information. The Global Information Infrastructure (GII) initiative is the integration and interaction of networks, information appliances, information resources, applications, and people. This infrastructure will provide information sharing between ISTAR, OGD, and Civil entities at varying levels of security and compartmentalization, a nontrivial challenge in itself. This information is required, indeed is the foundation for, the net-ready infrastructure discussed previously as well as a key enabler of Shared Awareness.

NEC forces will have access to many effectors within the battlespace that go beyond the traditional “attrition” effectors. Strand 3 in Figure 5 highlights that information operations is a large part of Effects Based Planning (EBP), providing the commander with operational flexibility. NEC will take a planning approach that focuses on the use of military and nonmilitary effects against an enemy. EBP must be integrated with other planning processes in the battlespace, operational through all levels in the MoD and in all government departments with impact on political, military, and economic aims. To do this will require dynamic, distributed planning systems to manage Agile Mission Groups. These planning systems consist of distributed tools and models to allow analyses across the operational domain to include interactions between military, diplomatic, and financial effects.

The formation of a net-ready force cannot be limited by equipment configurations based on existing organizational structures. Strand 4 in Figure 6 shows that an NEC force will consist of integrated capability components (weapon systems, ISTAR systems, and C2 systems) to facilitate formation of Agile Mission Groups to enable Flexible Working. These agile groups are brought together for specific operational tasks, each with its own set of unique support requirements. Once complete, elements of the agile groups return to their host organization. The Shared Awareness within an Agile Mission Group must be very high to facilitate understanding and achievement of its common goal.

As Strand 5 in Figure 7 indicates, NEC enables the concept of fully networked enterprise support. This support is not restricted to in-theatre forces but includes

![Figure 4. Information infrastructure strand.](image-url)
Figure 5. Effects-based planning strand.

Figure 6. Integrated capability components strand.
nonoperational entities such as government bodies, industry, academia, and public services. Through networking, all of these disparate entities may be brought to bear in support of in-theater capability. This includes support such as logistics, data/image analysis, and medical. These support "forces" are necessary to sustain the Agile Mission Groups, support Flexible Working, and, like all other strands, ultimately underpin the delivery of military and non-military effects.

5. CONCLUSION

This paper has shown a methodology that transforms the complexity of the NEC SoS into a systemic visualization using the systemigram conceptual modeling technique. As one analyzes each of the NEC strategy strands in the model, elements of communication, holism, hierarchy, and boundary emerge in the context of the core NEC themes. Such a perspective would not be evident from strict prose or any single architecture framework view. Whereas traditional words and pictures represent a positivist ontology of objective systems in the real world, systemigrams represent a phenomenologist ontology, in this case the various stakeholder world views of NEC which provides the catalyst for meaningful dialog. The systemigram model should be refined through storyboarding, working with the stakeholders in an iterative process of refinement until a comprehensive, coherent understanding of NEC strategy emerges.

6. GLOSSARY

BBC British Broadcasting Corporation
BPA Business Process Architecture
BSSM Boardman Soft Systems Methodology
CATWOE Mnemonic for Customers, Actors, Transformation, Weltanschauung, Owners, Environment
C2 Command and Control
C4ISR Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CE Concurrent Engineering
CSH Critical Systems Heuristics
CST Critical Systems Thinking
DII Defense Information Infrastructure
DLO Defense Logistics Organization
DMM Dialog Mapping Methodology
DoD Department of Defense
<table>
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>DoDAF</td>
<td>Department of Defense Architecture Framework</td>
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<tr>
<td>DPA</td>
<td>Defense Procurement Agency</td>
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<tr>
<td>EBO</td>
<td>Effects Based Operations</td>
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<td>EBP</td>
<td>Effects Based Planning</td>
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<td>GII</td>
<td>Global Information Infrastructure</td>
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<td>HAS</td>
<td>Human Activity System</td>
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<td>HLOC</td>
<td>High Level Operational Concept</td>
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<tr>
<td>IM</td>
<td>Interactive Management</td>
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<tr>
<td>ISM</td>
<td>Interpretive Structural Modeling</td>
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<tr>
<td>ISTAR</td>
<td>Intelligence, Surveillance, Target Acquisition, and Reconnaissance</td>
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<td>JC2SS</td>
<td>Joint C² Support System</td>
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<td>JOP</td>
<td>Joint Operational Picture</td>
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<td>JSP</td>
<td>Joint Service Publication</td>
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<td>MoD</td>
<td>Ministry of Defense</td>
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<td>MoDAF</td>
<td>Ministry of Defense Architecture Framework</td>
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<td>MS</td>
<td>Management Science</td>
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<td>NEC</td>
<td>Network Enabled Capability</td>
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<tr>
<td>OGD</td>
<td>Other Government Department</td>
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<tr>
<td>OR</td>
<td>Operational Research</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<td>SAFE</td>
<td>Systemic Analysis through Familiar Entities</td>
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<td>SAST</td>
<td>Strategic Assumptions Surfacing and Testing</td>
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<td>SCA</td>
<td>Strategic Choice Approach</td>
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<tr>
<td>SDR</td>
<td>Strategic Defense Review</td>
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<tr>
<td>SDR-NC</td>
<td>Strategic Defense Review – New Chapter</td>
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<tr>
<td>SODA</td>
<td>Strategic Options Development and Analysis</td>
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<tr>
<td>SoS</td>
<td>System of Systems</td>
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<td>SoSM</td>
<td>System of Systems Methodology</td>
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<td>SSM</td>
<td>Soft Systems Methodology</td>
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<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities, and Threats</td>
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<tr>
<td>TSI</td>
<td>Total Systems Intervention</td>
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<tr>
<td>XP</td>
<td>Extreme Programming</td>
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