Chapter 3
Systemic Thinking

Abstract As machine age problems have given way to systems age messes, the underlying complexity associated with understanding these situations has increased exponentially. Accordingly, the methods we use to address these situations must evolve as well. Unfortunately, however, many antiquated methods for dealing with situations remain prominent. Systems engineering is traditionally viewed as the practical application of procedural problem solving, typically geared toward the acquisition of large-scale systems. The underlying paradigm for solving problems with this approach, and other similar approaches, can be characterized as *systematic thinking*. While quite appropriate for machine age problems, it lacks the theoretical rigor and systemic perspective necessary to deal with systems age messes. Thus, a new paradigm of *systemic thinking*, conceptually founded in systems theory, is necessary. This chapter provides a brief historical background on the development of systems approaches, contrasts systems approaches and systems engineering and their underlying paradigm with systemic thinking, and introduces practical guidelines for the deployment of a systemic thinking approach that will provide the foundation for the remainder of this book.

3.1 A Brief Background of Systems Approaches

While we don't intend for this text to represent a purely engineering-centric perspective, both authors are engineers by training and we would be remiss if we didn't address the contribution that systems engineering has made in the formulation of our thoughts about this text (both positive and negative). An understanding of the evolution of systemic thinking must first begin with a brief introduction to systems engineering [6], from which systemic thinking derives its roots. To start, a definition of what is intended by the term *systems engineering* is necessary. Many definitions exist for systems engineering; we adopt the one provided by the Institute of Electrical and Electronics Engineers (IEEE) both for its brevity

P. T. Hester and K. M. Adams, *Systemic Thinking*, Topics in Safety, Risk, Reliability and Quality 26, DOI: 10.1007/978-3-319-07629-4_3,

and for the IEEE's recognition and role in providing high-quality standards for the practice of systems engineering. The IEEE standard for systems and software vocabulary defines systems engineering as the "interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a solution and to support that solution throughout its life" (IEEE and ISO/IEC [39, p. 361]). It is clear that such a perspective is not predicated on an engineering-centric viewpoint and thus, is in line with the discipline-agnostic aim of this book.

The two earliest books on engineering for systems were written by Goode [1909–1960] of the University of Michigan and Machol [1917–1998] of Purdue University [32] and Hall [1925–2006] of Bell Telephone Laboratories [33]. Goode and Machol list 145 references and make no reference to any other books on the engineering of systems. The closest they come is to reference two texts on Operations Research [48, 54]. Hall lists two texts on the engineering of systems [26, 32] and two on Operations Research [23, 54]. It is interesting to note that the book by Flagle et al [26] retained Operations Research in the lead position in the title, despite its focus on the engineering of systems.

A review of the Goode and Machol text shows a great deal of emphasis on probability, the design of experiments, and a variety of mathematical problem solving techniques drawn from Operations Research. Goode and Machol also touch briefly on information theory, cybernetics, servomechanism theory, and human engineering.

In 1962, Hall published the second text on systems engineering. Hall's topics included three new areas of emphasis: (1) the concept of value in decision making, including extensive discussion of economics, (2) a comprehensive, integrated general methodology for systems engineering, and (3) a discussion of the fundamental concepts of systems. The inclusion of economics as a core element of decision making is a change from Goode and Machol, who had relegated the topic of economics to the epilogue of their text. Hall formally introduces econometrics as an essential part of large-scale formal analysis methods. He also introduces a formal methodology for the analysis and synthesis of large scale systems. This methodology continues to act as the framework for many of the current systems engineering models in use today. Possibly the most significant new element is Hall's inclusion of a discourse on some fundamental concepts for engineering systems. Hall [33] states:

> It happens that certain properties apply to systems in general, irrespective of the nature of the systems or of the fields in which they are normally studied. While it is true that not all of the most general properties are useful in an operational sense for applied work, they have considerable conceptual value in more deeply understanding creative or developmental processes. This fact is the real justification for including them in this chapter (p. 59)

Hall [33] acknowledges the notion of a general systems theory and states that " …sometimes very difficult systems problems are greatly illuminated by looking at them in the light of the appropriate generalized property" (p. 65). Hall's book remained the major text for engineering systems for a number of years. It is worth noting that both Hall's and Goode and Machol's texts on the subject of systems engineering are substantially more general in nature than their successors and do not predicate their discussion on engineering disciplines. To them, *engineering is problem solving*; there is no distinction. To think about engineering systems was to think about how systems interacted with one another, how they functioned, how they could be understood, designed, and improved. This perspective has changed, however, as systems engineering has moved to a more process-focused discipline; engineering became proceduralized problem solving. Indeed, arguably the three most widely used academic text books on engineering of systems, as of this writing, are:

- *Systems Engineering and Analysis* by Benjamin Blanchard and Wolter Fabrycky of Virginia Polytechnic Institute and State University.
- *Systems Engineering: Principles and Practice* by Alexander Kossiakoff, William Sweet, Sam Seymour and Steven M. Biemer of the Johns Hopkins Applied Physics Laboratory.
- *Introduction to Systems Engineering* by Andrew Sage of George Mason University and James Armstrong of the United States Military Academy.

Each of these texts expends substantial intellectual resources discussing the *process* of systems engineering. That is, current systems engineering practice, most appropriately, can be characterized as *systematic engineering*, where *systematic* connotes the methodical, process-based nature of processes for systems engineering espoused by organizations such as the Department of Defense's Defense Acquisition University (DAU) [25] and NASA [55] steeped in their practice and *engineering* connotes the practical application of scientific principles reflected in those same organizations. Thus, systems engineering, as currently practiced, is by and large the practical application of procedural problem solving (most traditionally problems concerning the acquisition of systems). Further, the underlying paradigm for solving these problems can be characterized as *systematic thinking*. Systems engineering is not the only method to complex problem solving that exists, of course; many other systems methods are in use as well. Jackson [41] portrays systems methods using a typology that has four Types: (1) goal seeking and viability; (2) exploring purposes; (3) ensuring fairness; and (4) promoting diversity, which are presented in Table 3.1.

Jackson [40] states that the role of systemic thinking in each of the methods "serves them by adding greater conceptual rigor within their theoretical formulations and/or by enabling translation of these formulations into guidelines for practical action" (p. 105). Many of them are focused on systematic approaches to gaining understanding. While systematic thinking is appropriate for machine age systems, it loses its effectiveness when problems increase in complexity as we transition to systems age messes. Thus, a new paradigm of *systemic thinking*, conceptually founded in systems theory, is necessary. This new paradigm must be discipline-agnostic and theoretically-derived, two foundations upon which our perspective of systemic thinking is founded.

Table 3.1 Systems-based methods based upon Jackson's framework

Approach	Systems method	Primary proponent(s) of the method
Type A: goal seeking and viability	Operations research	[36]
	Systems analysis	[31]
	Systems engineering	[13, 56]
	System dynamics	[28–30, 44]
	Soft systems thinking	[57]
	Viable system model	[9–11]
	Complexity theory	[42, 60]
Type B: exploring purposes	Social systems design	[21, 22]
	Strategic assumption and surfacing technique (SAST)	[45, 46, 51–53]
	Interactive planning	[1, 4]
	Soft systems methodology	[18, 19]
Type C—ensuring fairness	Critical systems heuristics	[63, 64]
	Team syntegrity	[12]
Type D—promoting diversity	Participatory appraisal of needs and the development of action (PANDA)	[62, 65, 66]
	Total systems intervention	[27]

3.2 What is Systemic Thinking?

Systemic thinking,[1] as a term, has been gaining traction in recent literature (e.g., [15, 35, 49, 50]), but it is our belief that the term has been used without specificity or universality. Our goal in this book is to articulate our unique perspective on systemic thinking which differentiates it from those systems approaches previously identified, and to demonstrate its utility in helping individuals to increase their understanding about problems and messes of any size, complexity, or discipline. The characteristics differentiating systematic thinking and systemic thinking, as we see them, are outlined in Table 3.2, with a discussion of each of the eight elements to follow.

3.2.1 Age

The first distinguishing characteristic separating systematic and systemic thinking concerns the age each is designed to address. The machine age was concerned

[1] Much of the text presented in Sect. **3.2** appeared previously in Hester and Adams [35]. Although we have retained the copyright to this text, the authors wish to acknowledge this publication.

Table 3.2 Characteristics of systematic versus systemic thinking

Element	Systematic thinking	Systemic thinking
Age	Machine	Systems
Unit of analysis	Problem	Mess (system of problems)
Stopping criteria	Optimization	Satisficing
Goal	Problem solution	Increased understanding
Underlying philosophy	Reductionism	Constructivism and reductionism
Epistemology	Analysis	Synthesis and analysis
Discipline scope	Multidisciplinary and interdisciplinary	Transdisciplinary
Approach	Prescriptive	Exploratory

with simple systems and the systems age is concerned with complex systems, or more approspriately for purposes of systemic thinking, messes. Refer to Chap. 2 for a further distinction of these characteristics. Ackoff [3] speaks of the inability of machine age paradigms to appropriately handle systems age messes. The relevant takeaway is that, when we are faced with a mess, we will be unable to appropriately address it with methods designed for solving machine age problems. While these methods, such as operations research and systems engineering, certainly have their place, this place is not in addressing systems age messes, which require methods, and an accompanying theoretical basis, that appreciate their complex nature.

3.2.2 Unit of Analysis

Systematic thinking focuses on a singular problem. Due to its broader scope, systemic thinking has a larger, more abstract unit of analysis, that of a mess [3]. A mess represents a system of problems. Thus, many problems are contained in a mess, but their analysis is not merely summative. Thus, analysis of a mess is exponentially more complicated than a singular problem. This relationship is depicted in Fig. 3.1.

In Fig. 3.1 there are five problems, P_1, $P_2 \ldots P_5$ and a mess, M_1, consisting of these five problems and their problem context. Succinctly, $M_1 = \text{f}(P_1, P_2 \ldots P_5)$. It is in the interaction of these constituent problems and their associated context where the mess truly arises:

> Problems are elements abstracted from messes; therefore, problems are to messes what atoms are to planets….the behavior of the mess depends more on how the solutions to its components problems interact than on how they act independently of each other [2, pp. 4–5]

Viewing this mess as a whole truly requires a systemic perspective.

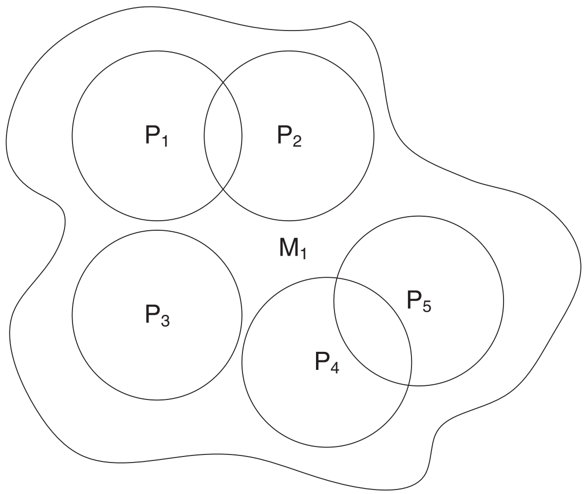

Fig. 3.1 Depiction of mess and constituent problems

3.2.3 Stopping Criteria

When analyzing a complex situation, it is imperative to think about global criteria associated with the desired end state of the analysis. That is, as a systems practitioner, am I searching for a globally optimal, "best (maximum or minimum) value of the objective function" [61], a singular *solution* to a problem, or am I merely seeking a satisfactory resolution to my problem? The answer, as always, depends.

Given the relatively constrained perspective of a singular problem, it is easy to conceive that the stopping criteria for a problem analysis using a systematic thinking paradigm is optimization. The end goal of this machine age problem is to develop a best answer to the problem at hand. Thus, we speak of the *best* design for a structural component of a larger system, or the *best* portfolio selection from among a number of choices. Systemic thinking, however, requires a more delicate balancing act to be observed. Given that any systemic thinking effort will involve two or more constituent problems, and the solution to each problem assessed independently represents a unique global solution to the mess, we must consider the principle of suboptimization [37] in our analysis of these messes. Maximizing overall mess performance (i.e., optimizing the mess) requires that its constituent problem solutions be constrained, thus violating the notion of suboptimization. Ackoff [2] echoes the difficulty in achieving an optimal solution to a mess:

> There is an important systems principle, familiar to all of you, that applies to messes and problems: that the sum of the optimal solutions to each component problem considered separately is not an optimal solution to the mess….It is silly to look for an optimal solution to a mess. It is just as silly to look for an optimal plan. Rather we should be trying to design and create a process that will enable the system involved to make as rapid progress as possible towards its ideals, and to do so in a way which brings immediate satisfaction and which inspires the system to continuous pursuit of its ideals (pp. 4–5).

Thus, if each system (i.e., problem) chooses to pursue (and thus, optimize) its own interests, then the mess will necessarily operate at less than maximum performance. Balancing the interests of constituent problems is one of the most difficult aspects of systemic thinking. A mechanism for doing so is known as *satisficing*. Satisficing is a term coined by Herb Simon [58, 59] to describe how individuals make rational choices between available options and within a constrained environment. Simon argued that decision makers are rarely able to obtain and evaluate all the information which could be relevant to the making of a decision. Instead, they work with limited and simplified information to reach acceptable compromises (you satisfice, a portmanteau of satisfy and suffice) rather than to obtain a globally optimal strategy where a particular objective is wholly maximized. This relaxation from optimal-seeking problem solution approaches represents a departure from traditional OR solution techniques, one appropriate for mess analysis.

3.2.4 Goal

Given systematic thinking's focus on the problem as a unit of analysis and optimization as its desired end state, it is clear that the goal of a systematic thinking endeavor is to determine a problem solution. As such, a problem solution effort aims to determine the globally best answer to the particular problem of interest and recognizes that there is a preferred solution for the endeavor in question. Systemic thinking endeavors, however, are not so straightforward. Given their focus on satisficing and messes, it is clear that a singular view of *best* is not only not achievable, but also not necessary. Instead, the goal of a systemic thinking endeavor is achieving increased understanding of a mess (recall the notion of perfect understanding discussed in the previous chapter; the assumption that we'll have complete understanding of our mess is both arrogant and foolhardy). Increased understanding does not presuppose that our situation will reach a conclusive state. Rather, we may end up trapped in a do-loop until conditions within our situation's environment change. Thus, the question we must ask is, how are we going to move toward increased understanding of our situation? This exploration may lead to a set of solutions, each of which may apply to the constituent problems of a mess, or it may lead simply to a greater understanding of the mess being faced. This increased knowledge may manifest itself in a recognition that we cannot do anything to improve or alter the current state. More importantly, perhaps, is the understanding that we may not want to intervene, for fear that we'll upset the dynamic equilibrium [24] of the underlying system. The field of cybernetics and the systems principle of homeostasis [17] inform systems practitioners that systems have the ability to self-regulate to maintain a stable condition. Often times, intervention will cause negative feedback rather than improvement. Understanding of this concept helps us to avoid the Type IV error [14] that we introduced in Chap. 1, where the correct analysis leads to an inappropriate action taken to resolve a problem. So, in achieving increased understanding we may learn that inaction is the best action. Hester [34] puts the notion of increased understanding in context by introducing the concept of finite causality, stating:

> …the outcome of the operation of any system is neither infinitely good nor infinitely bad. As more information is gained, the expected bounds surrounding this range of potential outcomes narrows, but never…meets at a point; in other words, it never reaches an optimal solution. Rather, the best we can hope to achieve is a set of potential outcomes that are boundedly rational and, by definition, neither infinitely good nor infinitely bad (p. 274).

So, we should not despair at the lack of a singular optimal solution, but rather continue to work toward increased understanding in an effort to reduce the bounds on our solution.

3.2.5 Underlying Philosophy

Philosophy is based in a world view which ultimately drives the understanding of a mess. Aerts et al. [7] define world view as "….a system of co-ordinates or a frame of reference in which everything presented to us by our diverse experiences can be placed" (p. 9).

Ackoff [5] discusses the concept of a world view as:

> Every culture has a shared pattern of thinking. It is the cement that holds a culture together, gives it unity. A culture's characteristic way of thinking is imbedded in its concept of the nature of reality, its world view. A change of world view not only brings about profound cultural changes, but also is responsible for what historians call a "change of age." An age is a period of time in which the prevailing world view has remained relatively unchanged (p. 4).

This consistency in world view is what Checkland [18] refers to as *weltanschauung*, the image or model of the world that provides meaning. Each of these definitions hints at the idea of a world view as a shared perspective or frame of reference for understanding the world. Ackoff's [3] talk of a transition in ages implies a shift in philosophical world view. The philosophical worldview has changed from reductionism in the machine age to constructivism in the systems age.

Reductionism, first introduced to Western civilization by René Descartes [1596–1650] in his *Discourse on Method* and later expanded by Isaac Newton [1643–1727] in his *Principia Mathematica* focuses on reducing a system to its barest elements in order to provide for an understanding of a system. Focusing on biological complexity, Mazzocchi [47] discusses several limitations of applying a purely reductionist perspective to understanding complex systems:

- *…the reductionist approach is not able to analyse and properly account for the emergent properties that characterize complex systems…* (p. 11)
- *…reductionism favours the removal of an object of study from its normal context. Experimental results obtained under given particular conditions or from a particular model—such as a mouse,* in vitro *cell cultures or computer models—are often extrapolated to more complex situations and higher organisms such as humans. But this extrapolation is at best debatable and at worst misleading or even hazardous.* (p. 12)

- *…reductionism is also closely associated with determinism—the concept that every phenomenon in nature is completely determined by preexisting causes, occurs because of necessity, and that each particular cause produces a unique effect and* vice versa*. This, naturally, also sustains the idea of predictability…. Nonetheless, complex…systems cannot be fully understood on a purely deterministic basis.* (p. 12)
- *…to better understand complex…systems and their adaptive behaviour, we need to consider the phenomenon of self-organization….* (p. 12)

Mazzocchi [47] continues:

> An epistemological rethink is needed to instigate a paradigm shift from the Newtonian model that has dominated science, to an appraisal of complexity that includes both holism and reductionism, and which relaxes determinism in favour of recognizing unpredictability as intrinsic to complex systems (p. 13).

It is clear that much is to be gained from adapting a world view focused on holism, or constructivism. This perspective focuses on assembling system components into a purposeful whole in order to provide for an understanding of the entire system. However, this isn't the only way to gain understanding. Within the construct of systemic thinking, we must first use reductionism to deconstruct our mess into discernible elements, understand these individual elements, and then use constructivism to rebuild them in an effort to gain a holistic understanding of our mess. This unique world view, focused on ***the use of both reductionism and constructivism***, underlies systemic thinking and helps to provide for its epistemological basis, discussed in the following section.

3.2.6 Epistemology

Epistemology refers to the theory of knowledge and thus, addresses how knowledge is gained about a particular situation. It is informed by a particular world view and thus, given their divergent world views, the epistemology underlying systematic and systemic thinking is quite divergent as well. Ackoff [3] succinctly describes the steps in analysis as:

> …(1) taking apart the thing to be understood, (2) trying to understand the behavior of the parts taken separately, and (3) trying to assemble this understanding into an understanding of the whole… (p. 8)

Analysis relies on observation, experimentation, and measurement for its knowledge gathering. It is largely quantitative in its attempts to explain and understand the world.

On the other end of the epistemological spectrum is synthesis. Synthesis involves identification of a system to be studied. It then explores the environment in which the system resides, in order to understand its behaviors and purpose. Thus, rather than decomposing the system, synthesis aggregates a system into larger and larger systems in order to infer meaning. Synthesis relies on understanding, complementarity of perspectives [16], and social construction for its meaning. Its emphasis on understanding (vice solution) and complementary, subjective evaluation of meaning should be comforting to individuals who focus on messes.

Neither epistemology alone is sufficient. We must invoke both synthesis and analysis, as appropriate, in order to increase our understanding of our mess and its constituent problems.

3.2.7 Disciplinary Scope

Although the terms are often erroneously used interchangeably, multidisciplinary, interdisciplinary, and transdisciplinary each have a unique meaning (see, e.g., [43, 67, 68]). A succinct summary of the three terms is provided by Choi and Pak [20]:

> We conclude that the three terms are used by many authors to refer to the involvement of multiple disciplines to varying degrees on the same continuum. Multidisciplinary, being the most basic level of involvement, refers to different (hence "multi") disciplines that are working on a problem in parallel or sequentially, and without challenging their disciplinary boundaries. Interdisciplinary brings about the reciprocal interaction between (hence "inter") disciplines, necessitating a blurring of disciplinary boundaries, in order to generate new common methodologies, perspectives, knowledge, or even new disciplines. Transdisciplinary involves scientists from different disciplines as well as nonscientists and other stakeholders and, through role release and role expansion, transcends (hence "trans") the disciplinary boundaries to look at the dynamics of whole systems in a holistic way (p. 359).

A graphical depiction of multidisciplinary, interdisciplinary and transdisciplinary is shown in Fig. 3.2. Note that D_1 and D_2 in the figures refer to Discipline 1 and Discipline 2, respectively.

A truly transdisciplinary scope is required for systemic thinking. This is further demonstrated by the holistic perspective demanded by systemic thinking. Multidisciplinary and interdisciplinary perspectives represent too narrow a focus for understanding the bigger picture encouraged by a systemic lens.

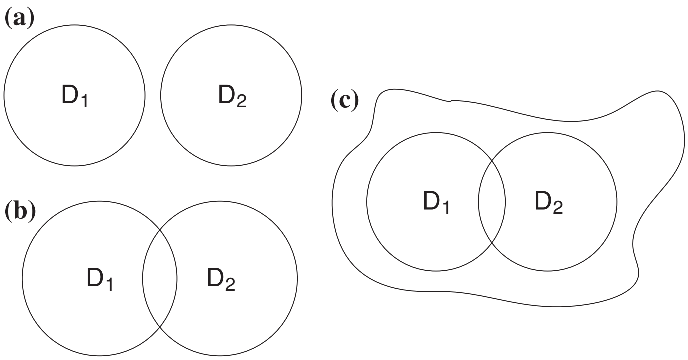

Fig. 3.2 **a** Multidisciplinary, **b** interdisciplinary, and **c** transdisciplinary depictions

3.2.8 Approach

The final distinguishing characteristic that separates systematic thinking from systemic thinking is that of the approach employed by each. As discussed earlier, systematic thinking is, quite obviously, systematic, and thus, procedural. This means it is largely prescriptive and largely holds to a detailed process for undertaking it. In the world of cooking, systematic thinking would involve strict adherence to a recipe; in driving, step-by-step navigation barked out by a GPS; in engineering, a standard such as IEEE Std. 1220 [38], with many rules and procedures to follow. Systemic thinking, on the other hand, is much more exploratory. It is normative in that it is driven by a flexible way of thinking which adheres to norms, or general descriptors of behavior without strict rules. The emergent behavior [8] exhibited by the messes it is intended to support are well suited to an exploratory approach. Thus, returning to previous examples, systemic cooking would suggest a general framework for a meal and perhaps a set of suggested ingredients, but it would refrain from providing precise measurement quantities or detailed instructions. Similarly, systemic navigation would account for emergent behavior expected by anyone who's ever gone anywhere in a car, and who has had to account for elements such as traffic, road construction, and weather. It might exist on a continuum, at one end merely providing a map with a *You are here* sticker and leaving the explorer to his or her devices, and at the end other end providing a set of suggested routes, but leaving the explorer to determine deviations from the suggested route in an ad hoc fashion and adjusting accordingly. Finally, with respect to engineering, systemic thinking provides a general methodology for *thinking* about a mess, yet it stops short of detailed prescription and procedural instructions necessary in traditional systematic endeavors. This lack of prescription allows for the systems practitioner to adjust to real world nuances impossible to be captured by prescriptive approaches to understanding complex scenarios. It is this general methodology that we now turn our attention to as the authors attempt to introduce a general approach for systemic thinking applicable to all messes.

3.3 A Methodology for Systemic Thinking

The key to *systemic thinking* is consideration of the "5 W's and How?" That is, who, what, why, where, when, and how? The relevance of each is explained below.

- *Who* is relevant to understanding our mess? *Who* concerns holistic consideration for the stakeholders involved in a situation. Stakeholder analysis and management is discussed in detail in Chap. 5.
- *What* are we trying to achieve in understanding our mess further? This concerns the mess itself. What are the outputs and outcomes we wish to achieve? These and other questions are discussed in Chap. 6.
- *Why* are we interested in this mess? We all only have 24 h in a day with which to expend our resources. Why does this mess demand our resources and efforts? What motivations exists for our involvement in this mess? These questions are discussed in Chap. 7.

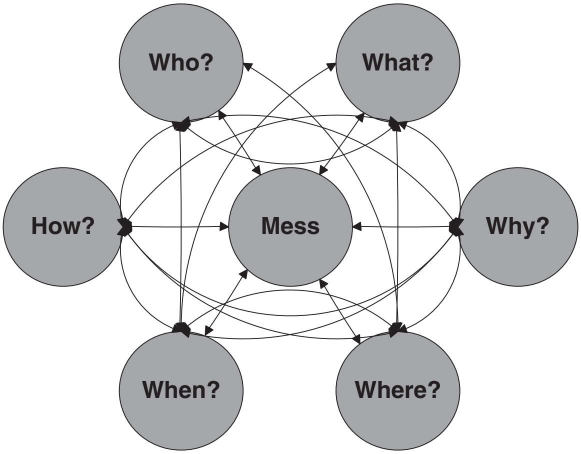

Fig. 3.3 Methodology for systemic thinking

- *Where* does our situation reside? What are the characteristics of the context of our mess? Where are the boundaries on our system? Attention is given to these elements in Chap. 8.
- *How* do we achieve improved understanding of our mess? This question discusses mechanisms for understanding our mess. How do we deploy mechanisms in order to achieve our aims? This is the focus of Chap. 9.
- *When* do we want to have increased mess understanding by? This question explores maturity- and stability-related concerns. When should we intervene in a system to create the largest impact? These questions are addressed in Chap. 10.

Finally, Chap. 11 brings all of these elements back together to demonstrate how to form a systemic perspective of a mess. Attempting to answer these questions forms the methodology for systemic thinking developed in this text. Figure 3.3 illustrates the interaction of these questions with one another.

While this figure seems innocent enough, one could imagine it increasing substantially in complexity if we were to decompose the mess as shown in Fig. 3.4. We have to account for the relationships between elements, e.g., the resources of one problem being tied to those of another. In these interactions and conflicts our mess truly arises.

Given that systemic thinking is exploratory in its approach, there is no singular starting point or initial step. However, in the absence of any predisposition for acting otherwise, the authors suggest starting with the *Who* step (Chap. 5) and proceeding through the chapters in a linear fashion. This will allow the reader the best opportunity for understanding the authors' approach to systemic thinking. It is important to note, however, that any step can lead to any other (as depicted in Fig. 3.3) and steps may (and often will) be revisited throughout the course of an analysis. Thus, the reader is encouraged to find a pattern that fits his or her own comforts. This pattern is likely to be mess-dependent, however, and attempting to always follow the same path may prove problematic. While we suggest in

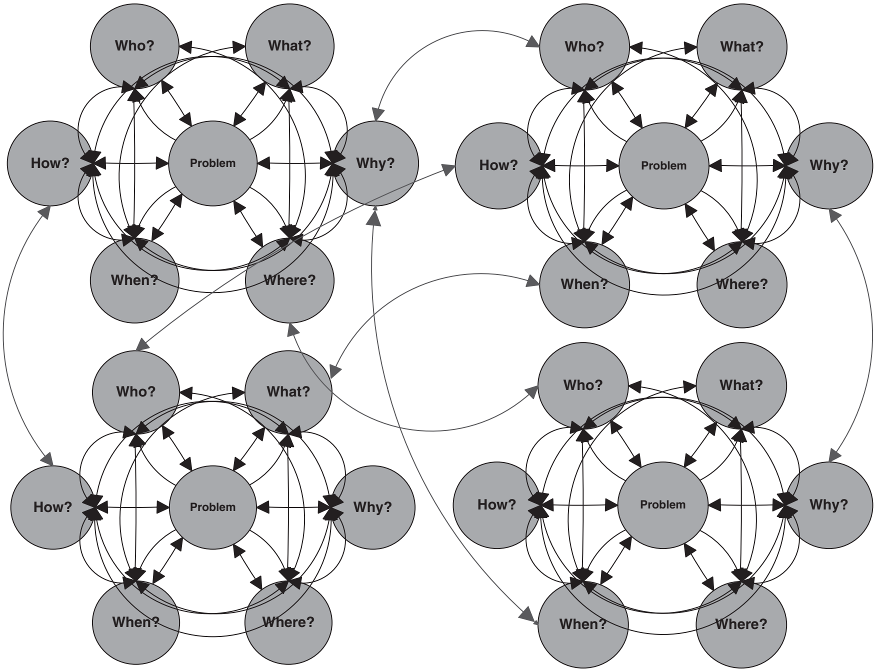

Fig. 3.4 Relationship among several problems and systemic thinking elements

the absence of other guidance to begin with stakeholder analysis and management (*Who?*), there may be reason to do otherwise. For example, stakeholders of your mess may be predetermined, with their roles clearly defined. Thus, it may behoove us to explore the *What* or the *Why* first. There is no wrong answer.

The flexibility of this approach owes itself to its foundation on the theoretical framework of systems theory. Systems theory provides the foundational underpinning for systemic thinking. This generalized theoretical underpinning provides rigor for the use of this approach by way of systemic thinking. This theory and its historical origins are discussed in detail in the following chapter.

3.4 Summary

Systems age messes are much grander and more complex than their machine age problem predecessors. Thus, accompanying methods to understand them must also account for this additional complexity. Practice shows that this is not the case and many methods and their underlying paradigms of systematic thinking are still quite prevalent in today's world. This chapter introduced a methodology for systems thinking and contrasted it with traditional systematic thinking. The aim of the remainder of this book is to present the methodology underlying systemic thinking such that the reader, upon completion, will understand how to put the approach into practice in a manner which will garner increased understanding for systems age messes.

After reading this chapter, the reader should:

1. Understand the evolution of systems approaches;
2. Be able to articulate the distinction between systematic and systemic thinking; and
3. Identify the six perspectives of systemic thinking.

References

1. Ackoff RL (1974) Redesigning the future: systems approach to societal problems. Wiley, New York
2. Ackoff RL (1977) Optimization + Objectivity = Opt Out. Eur J Oper Res 1(1):1–7
3. Ackoff RL (1979) The future of operational research is past. J Oper Res Soc 30(2):93–104
4. Ackoff RL (1981) Creating the corporate future—plan or be planned for. Wiley, New York
5. Ackoff RL (1999) Re-creating the corporation: a design of organizations for the 21st century. Oxford University Press, New York
6. Adams KM, Mun JH (2005) The application of systems thinking and systems theory to systems engineering. In: Proceedings of the 26th national ASEM conference: organizational transformation: opportunities and challenges. American Society for Engineering Management, Virginia Beach, VA, pp 493–500
7. Aerts D, Apostel L, De Moor B, Hellemans S, Maex E, Van Belle H et al (1994) World views: From fragmentation to integration. VUB Press, Brussels
8. Aristotle (2002) Metaphysics, book h—form and being at work, 2nd edn. Green Lion Press, Sante Fe
9. Beer S (1979) The heart of enterprise. Wiley, New York
10. Beer S (1981) Brain of the firm. Wiley, New York
11. Beer S (1985) Diagnosing the system for organizations. Wiley, Chichester
12. Beer S (1995) Beyond dispute: the invention of team syntegrity. Wiley, New York
13. Blanchard BS, Fabrycky WJ (2011) Systems engineering and analysis, 5th edn. Prentice Hall, Upper Saddle River, NJ
14. Boal K, Meckler M (2010) Decision errors of the 4th, 5th and 6th kind. In: Nutt PC, Wilson DC (eds) Handbook of decision making. Wiley, West Sussex, pp 327–348
15. Boardman J, Sauser B (2013) Systemic thinking: building maps for worlds of systems. Wiley, New York
16. Bohr N (1928) The quantum postulate and the recent development of atomic theory. Nature 121(3050):580–590
17. Cannon W (1929) Organization for physiological homeostasis. Physiol Rev 9(3):399–431
18. Checkland PB (1993) Systems thinking, systems practice. Wiley, New York
19. Checkland PB, Scholes J (1999) Soft systems methodology in action. Wiley, Chichester
20. Choi BCK, Pak AWP (2006) Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. definitions, objectives, and evidence of effectiveness. Clin Invest Med 29(6):351–364
21. Churchman CW (1968) The systems approach (revied and updated. Dell Publishing, New York
22. Churchman CW (1979) The design of inquiring systems: basic concepts of systems and organization. Basic Books, New York
23. Churchman CW, Ackoff RL, Arnoff EL (1957) Introduction to operations research. Wiley, New York
24. D’Alembert J (1743) *Traité de Dynamique* Paris: David l’Ainé

25. DAU (2001) Systems engineering fundamentals. Defense Acquisition University Press, Fort Belvoir
26. Flagle C, Huggins W, Roy R (1960) Operations research and systems engineering. Johns Hopkins Press, Baltimore
27. Flood RL, Jackson MC (1991) Creative problem solving: total systems intervention. Wiley, New York
28. Forrester JW (1961) Industrial dynamics. MIT Press, Cambridge
29. Forrester JW (1969) Urban dynamics. MIT Press, Cambridge
30. Forrester JW (1971) World dynamics. MIT Press, Cambridge
31. Gibson JE, Scherer WT, Gibson WE (2007) How to do systems analysis. John Wiley & Sons, New York
32. Goode H, Machol R (1957) Systems engineering: an introduction to the design of large-scale systems. McGraw-Hill Book Company, New York
33. Hall AD (1962) A methodology for systems engineering. D. Van Nostrand Company Inc, Princeton
34. Hester PT (2012) Why optimization of a system of systems is both unattainable and unnecessary. Int J Syst Syst Eng 3(3/4):268–276
35. Hester PT, Adams KM (2013) Thinking systemically about complex systems. Procedia Comput Sci 20:312–317
36. Hillier FS, Lieberman GJ (2009) Introduction to operations research, 9th edn. McGraw-Hill, New York
37. Hitch CJ (1953) Sub-optimization in operations problems. J Oper Res Soc Am 1(3):87–99
38. IEEE (2005) IEEE Standard 1220: systems engineering—application and management of the systems engineering process. Institute of Electrical and Electronics Engineers, New York
39. IEEE ISO/IEC (2010) IEEE and ISO/IEC Standard 24765: systems and software engineering—Vocabulary New York and Geneva: Institute of Electrical and Electronics Engineers and the International Organization for Standardization and the International Electrotechnical Commission, pp 1–418
40. Jackson MC (2000) Systems approaches to management. Kluwer Academic, New York
41. Jackson MC (2003) Systems thinking: creative holism for managers. Wiley, Chichester
42. Kauffman SA (1995) At home in the universe: the search for laws of self-organization and complexity. Oxford University Press, New York
43. Lawrence RJ (2004) Housing and health: from interdisciplinary principles to transdisciplinary research and practice. Futures 36:487–502
44. Maani KE, Cavana RY (2000) Systems thinking, systems dynamics: understanding change and complexity. Prentice-Hall, Auckland
45. Mason RO (1969) A dialectical approach to strategic planning. Manage Sci 15(8):B403–B414
46. Mason RO, Mitroff II (1981) Challenging strategic planning assumptions: theory, cases and techniques. Wiley, New York
47. Mazzocchi F (2008) Complexity in biology: exceeding the limits of reductionism and determinism using complexity theory. EMBO Rep 9(1):10–14
48. McCloskey J, Trefethen F (1954) Operations research for management. Johns Hopkins Press, Baltimore
49. Midgley G (2012) Systemic intervention: philosophy, methodology, and practice. Springer, New York
50. Mingers J (2010) Realising systems thinking: knowledge and action in management science. Springer, New York
51. Mitroff II, Barabba CP, Kilmann RH (1977) The application of behavorial and philosophical techniques to strategic planning: a case study of a large federal agency. Manage Sci 24(1):44–58
52. Mitroff II, Emshoff JR (1979) On strategic assumption-making: a dialectical approach to policy and planning. Acad Manage Rev 4(1):1–12
53. Mitroff II, Emshoff JR, Kilmann RH (1979) Assumptional analysis: a methodology for strategic problem solving. Manage Sci 25(6):583–593
54. Morse P, Kimball G (eds) (1951) Methods of operations research. Wiley, New York

55. NASA (2007) Systems engineering handbook. National Aeronautics and Space Administration, Washington
56. Sage AP (1992) Systems engineering. Wiley, New York
57. Senge PM (1990) The fifth discipline: the art and practice of the learning organization. Doubleday, New York
58. Simon HA (1955) A behavioral model of rational choice. Quart J Econ 69(1):99–118
59. Simon HA (1956) Rational choice and the structure of the environment. Psychol Rev 63(2):129–138
60. Stacey RD (1992) Managing the unknowable: strategic boundaries between order and chaos in organizations. Jossey-Bass, San Francisco
61. Taha HA (2011) Operations research: an introduction, 9th edn. Prentice Hall, Upper Saddle River
62. Taket AR, White LA (1993) After or: an agenda for postmodernism and poststructuralism in or. J Oper Res Soc 44(9):867–891
63. Ulrich W (1983) Critical heuristics of social planning: a new approach to practical philosophy. Wiley, New York
64. Ulrich W (1988) Systems thinking, systems practice, and practical philosophy: a program of research. Syst Pract 1(2):137–163
65. White LA, Taket AR (1997) Beyond appraisal: participatory appraisal of needs and the development of action (PANDA). Omega 25(5):523–534
66. White LA, Taket AR (2000) Exploring the use of narrative analysis as an operational research method: a case study in voluntary sector evaluation. J Oper Res Soc 51(6):700–711
67. Whitfield K, Reid C (2004) Assumptions, ambiguities, and possibilities in interdisciplinary population health research. Can J Public Health 95:434–436
68. Young CA (1998) Building a care and research team. J Neurol Sci 160(Suppl 1):S137–S140